24, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Mobility of Cross-Country Vehicles

Contents, Page 3

Your order can be this small. **One self-lubricating bearing, custom made. You'll get the same prompt, interested service as you would if you ordered Bound Brook bearings by the ton.**

BOUND BROOK

Bound Brook Oil-less Bearing Co., Bound Brook, N. J.
Pioneer in Powder Metallurgy Bearings and Parts.
Plants at Bound Brook, N.J. and Sturgis, Mich.

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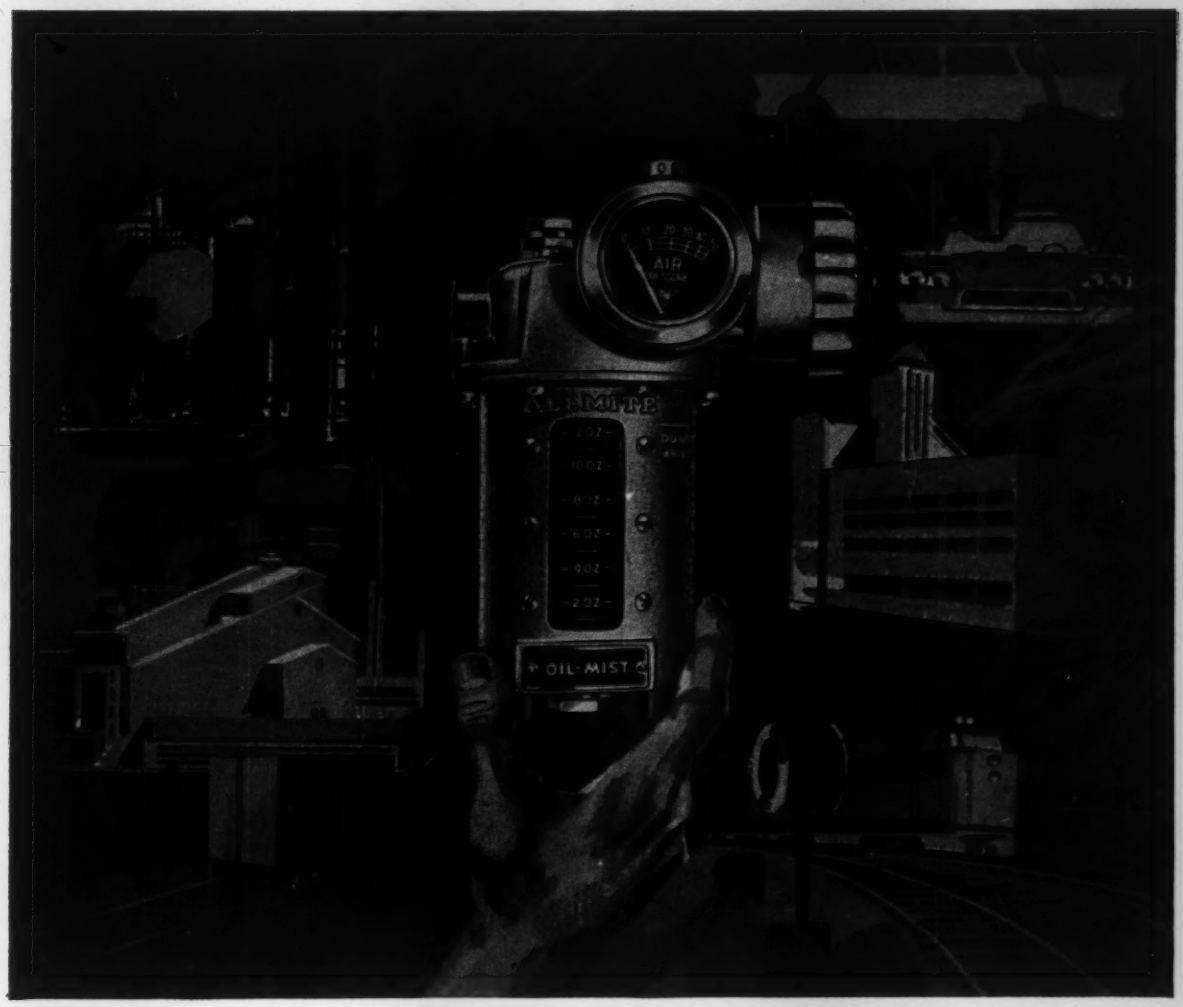

WHY 500 BLUE CHIP COMPANIES LUBRICATE COSTLY MACHINERY WITH ALEMITE OIL-MIST SYSTEMS

An Alemite Oil-Mist Lubrication System provides safe, foolproof, automatic lubrication . . . increases machine output . . . reduces lubrication costs.

Designed for a wide range of applications. Oil-Mist provides constant, uniform lubrication of many sizes and types of bearings, from small sewing machine bearings to large steel mill back-up roll bearings or work roll bearings. Open type and enclosed gear trains and chain drives are lubricated by Oil-Mist when leakage problems exist. An Oil-Mist System is also ideal for lubricating slides, ways and cams, where a minimum of continuous lubrication is required.

Used in both large and small plants. Alemite Oil-Mist Systems are now operating in hundreds of plants . . . reducing operating temperatures and bearing wear . . . eliminating housekeeping problems and contamination due to over-lubrication . . . reducing man-hours and down-time. Check *your* plant. Perhaps you, too, can benefit from the many important advantages of a modern Oil-Mist System.

Cut costs . . . reduce man-hours and machine down-time . . . extend bearing life . . . increase production . . . with a modern Alemite Oil-Mist Lubrication System

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Dept. BB-129, 1850 Diversey Parkway, Chicago 14, Illinois

Symbol of SW Excellence

ALEMITE DIVISION
STEWART-WARNER CORPORATION

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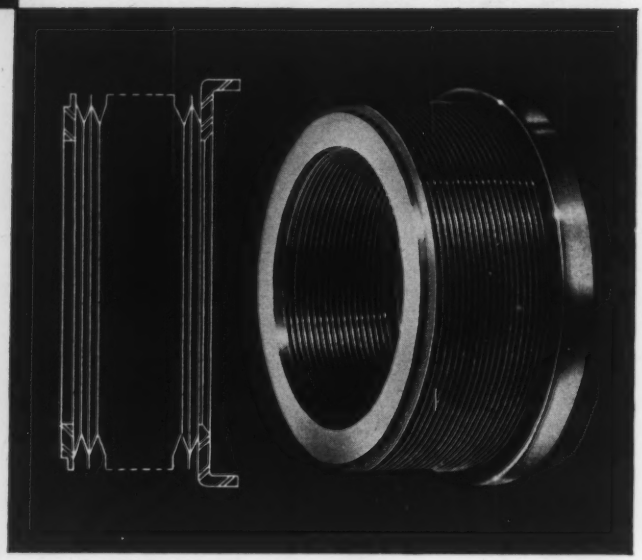
C/R DESIGN NOTES

How C/R's New Metal Bellows Seal Meets Seemingly Impossible Operating Conditions



Operating Ranges

Temperature	−400° to 1000° F.
Pressure	500 psi
R.P.M.	80,000 plus

These known operating ranges indicate the function of this seal. It is designed for applications where temperatures and mediums to be sealed forbid the use of any organic materials. Typically, these applications include fuel pumps, compressor power units and turbine starters characteristic in rockets and missiles. Other applications include mechanisms which are exposed to a high level of radioactivity.

Design Advantages

The C/R metal bellows seal consists of a metal bellows — a welded homogeneous unit which is secured at one end — and a carrier ring in which the sealing face is mounted. The seal does not contact the shaft. It is stationary, and the only rubbing surfaces are the sealing face and mating ring. These surfaces are precision lapped to provide a positive seal with minimum friction. At any given pressure, the seal can be designed to maintain proper and constantly effective face loads. It orients immediately to run-out and will resist any torques it is subjected to in operation. The design has high end-play tolerance: Chicago Rawhide engineers have deflected a bellows .100 in. for three million cycles at 1750 cpm and at a temperature of 500° F. with no adverse effects.

A further advantage is relatively light weight and compactness. The C/R metal bellows seal can be designed for minimum axial and radial space. Axially, complete seals can be produced within a ¼ in. cross-section. Radially, dimensions are comparable with conventional end face seals.

The C/R metal bellows seal can also be designed with an extremely low coefficient of expansion. The importance of this factor becomes apparent with the fact that in many applications the operating temperature may change hundreds of degrees in a very few seconds.

Mediums To Be Sealed

Virtually any known liquid or gas may be positively sealed with this design, depending upon duration or service life. From a practical viewpoint, the C/R metal bellows seal is the best design for the sealing of cryogenic and high-energy fuels such as LOX, hydrogen peroxide, fluorine and other missile and rocket propellants.

Where possible, lubrication of the two sealing faces is desirable to prolong service life. However, the medium being sealed commonly acts as the lubricant and may be merely hot gas.

Materials

Sealing faces and mating rings for the C/R metal bellows seal are available in a variety of materials including carbons, carbides, ceramics and various alloyed metals for both high temperature and corrosion resistance. The bellows can be furnished in any of several metals and alloys such as stainless steel, Monel, Inconel X, Ni-Span C and other special alloy steels.

Consult C/R Engineers

Each application for the C/R metal bellows seal is essentially a custom-design and an intimate knowledge of all conditions to be encountered must be known by Chicago Rawhide engineers to produce the correct combination of properties in the seal. Then, whether you require five, fifty or five thousand seals, Chicago Rawhide will design and produce the correct seal to solve your problem.

Helpful Design Data:

We will gladly furnish you with a design guide and space envelope data concerning the C/R Metal Bellows Seal. Just write for Bulletin MBS-1 on your company letterhead.

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1221 Elston Avenue • Chicago 22, Illinois

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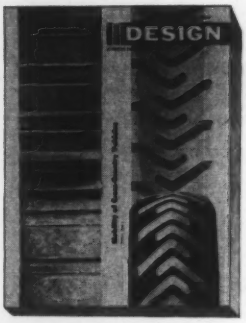

Front Cover: Creating a heavy impression in George Farnsworth's cover design are a track and a wheel, two elements of cross-country vehicles studied in M. G. Bekker's series of articles starting on Page 92.

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Double Fatigue Life for Threaded Fasteners 24

News Report—New thread form for high-tensile, self-locking nuts increases endurance and reliability of bolted assemblies under fatigue-loading conditions.

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How to avoid a common cause of machine downtime

Even well designed and engineered machines can turn out to be big headaches. Common cause: Downtime due to excessive maintenance of electric controls.

Electrically operated machinery is only as good as the controls which govern its operation. Minimum electrical maintenance means less machine downtime.

Hint: To insure maximum operating efficiency for *your* machinery, check the above photograph. It shows the contact tips (at right) from a Clark Type "CY" A-C Motor Starter after one year of continuous service with frequently as many as 5,000 operations per hour. Compare them with the new, unused tips at left above.

See for yourself that except for slight discoloration and minute pitting the used contact tips show very little evidence of wear even after one year of steady operation. Many more years of reliable, maintenance-free (and downtime-free) service are assured.

Clark's exclusive "arc quenching" principle, which works through the use of strong, multi-turn magnetic blowouts and double-break contacts, is the answer.

The action of the magnetic field not only forces the arc to rotate, moving it continually over contact surfaces, but tends to "quench" it at the same time. As a result, there's less wear on contact tips and a substantial reduction in maintenance requirements — much less machine downtime.

There are many more good reasons why the Clark Type "CY" Starters will control your machines better — help them to put their "best foot forward" and keep it there. For *all* the facts on Clark "CY" Starters, as well as space-saving "PM" Relays and other controls in Clark's "standard of quality" line contact your nearest Clark Controller sales office or distributor. Or, write direct.

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ENGINEERING NEWS

High-Heat Materials Readied For Leading Edges, Electronics

Dyna-Soar May Get Molybdenum; Diodes Use Gallium Phosphide

NEW YORK—Sheet and "sandwich" structures of molybdenum are rapidly approaching sizes which will actually be needed for manned space vehicles of the Dyna-Soar type. Prototype aerodynamic structures hoped to withstand anticipated 3000 F re-entry temperatures are already being fabricated by the Finn Aeronautical Division of Astrometals Corp., Hawthorne, N. J.

In contrast with "inch-size" samples fabricated from the refactory metal up to now, Finn plans to prepare prototype structures limited in size only by practical limitations of available molybdenum (0.5Ti) sheet. Current activity is concentrated on production of prototype leading edges for wing and tail surfaces of space craft. A section of molybdenum leading edge was exhibited recently by the company at NASA's 1959 Inspection.

Molybdenum is coveted for space-vehicle use because of its high strength at temperatures a thousand degrees above the heat limitations of other materials. One of the biggest obstacles to its fabrication—a successful welding technique—was recently licked at Finn, and weldments with good ductility and strength are produced.

Hot Transistors

A rare material called gallium phosphide, which will withstand temperatures ranging to 1500 F, may help beat heat encountered by electronic parts in missile nose cones. Army Signal Corps has built an electronic diode using this material which has lived through temperatures seven times higher than the heat limits of silicon and germanium used in present diodes.

"The material may also be used in building solar-cell power plants for space stations," according to Brigadier General J. C. Monahan, Chief of the U. S. Army Signal Corps Research and Development Division. "As a rugged core of tiny electrical devices, it may be used in making electronic parts for missiles, satellites, and deep space probes."

Resembling yellow ground glass, gallium phosphide is being "homegrown" at the Army Signal Research and Development Laboratory, Fort Monmouth, N. J. The material is composed of two chemical elements which, when apart, melt at low temperatures. Gallium, a rare silvery metal that costs about $1500 per lb in pure form, melts in the hand. Common phosphorous, used in matches and fireworks, also melts easily. However, laboratory scientists have combined the elements for use in the experimental diode and in switching devices which promise to operate successfully at intense temperatures.

The material is still under study to further pin-point its unique properties before release to Signal Corps equipment-development engineers.

Educator Wins New ASME Award

First man to receive ASME's Machine Design award—"in recognition of eminent achievement or distinguished service in the field of machine design"—is Charles E. Crede (center), associate professor of mechanical engineering, California Institute of Technology. Professor Crede accepted the honor during ASME's annual meeting, Dec. 2, where he was cited as an "inspired leader in the field of shock and vibration, who through eminent achievement by creative contributions in the research, development and application of shock mounts, has advanced the field of machine design and furthered the interest and study in shock and vibration control . . ." Presentation of the award which will now become an annual event, was made by Glenn B. Warren (left), ASME president, and Jesse W. Huckert (right), president of the Society's Machine Design division.

The Prime Mover Company, manufacturer of materials handling equipment, says:

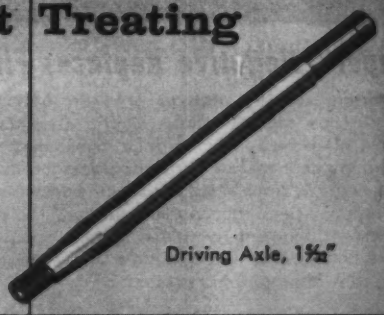
Our "Prime Movers" give these 6 parts a terrific beating...that's why they're made of LaSalle

STRESSPROOF®
STEEL BARS
with copper

Strength Without Heat Treating

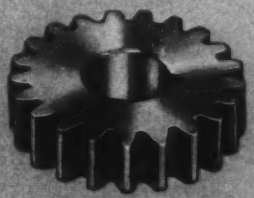
Worm Shaft, 1½"

Input Shaft, 1 5/32"

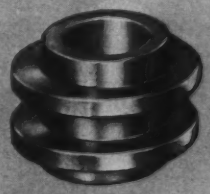


Driving Axle, 1 5/32"

Shifting Shaft, ¾"



Reverse Pinion, 3"



Bearing Carrier
Clutch Throwout, 2¼"

Engineers of the Prime Mover Company, Muscatine, Iowa, demanded the most dependable steel bars available for six important parts of their transmission assembly. Here are some of the reasons they specified STRESSPROOF!

You don't have to heat treat STRESSPROOF! There's no heat treat distortion.

STRESSPROOF is strong . . . 100,000 psi.

It machines faster . . . at 83% the speed of B1112.

It wears better without case hardening . . . replacing .40 carbon alloy steels and other heat treated and alloy steels, such as 8640, 4140, C1045, C1141, and C1137.

It costs less than heat treated in-the-bar alloys.

Use this coupon to request technical bulletin announcing improvements in LaSalle STRESSPROOF *Steel Bars...with copper.*

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Please send technical bulletin "Today's Improved LaSalle STRESSPROOF Steel Bars...with Copper."

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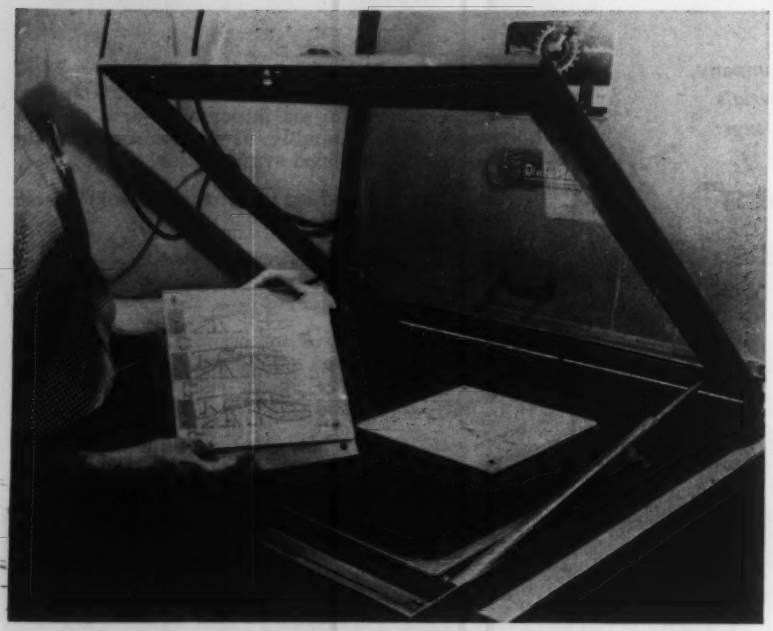
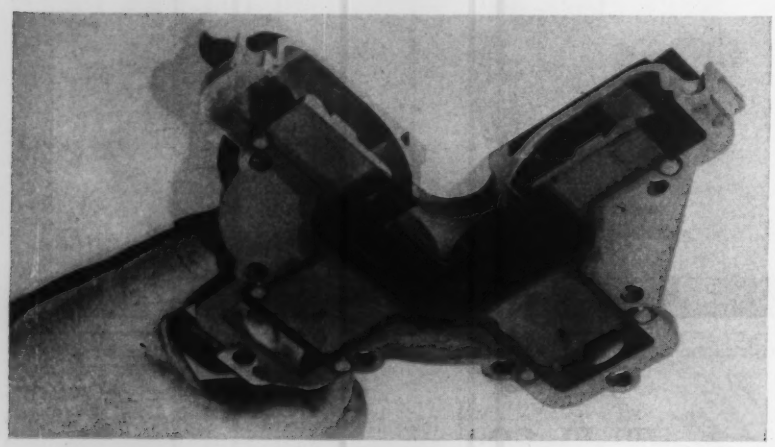


"Paper" Negative Replaces Film in Circuitry Pattern

Transferring circuitry patterns onto circuit boards is done with paper negatives at Librascope Inc., Glendale, Calif. This new method eliminates objectionable features of ordinary photographic film, which can stretch or shrink if temperature or humidity changes and is easily damaged during handling. The reversed image of the circuit is transferred onto thin, translucent paper stock which is then bonded to a rigid piece of transparent plastic. The plastic backing also makes possible automatic alignment with the circuit board—alignment holes at the board's corners and pins at the backing's corners match up and hold the board in place during the photographic process.



Critical Pump Parts Glued Together

Three separate castings, bonded with adhesive, take the place of one complex casting—and form a neat solution to a tough fabricating problem faced by a pump manufacturer. The result: Rejection rate for the particular part has been cut from 25 per cent to almost zero. The adhesive was chosen over mechanical types of fasteners because it eliminates the need for studs, bolt holes, and flanges. It also effectively seals the sections, so no gaskets or separate seals are needed. The adhesive used—a one-part, high-strength compound with an epoxy resin base, called EC-1386—was developed by Minnesota Mining & Mfg. Co.

Topics

Clos make the spaceman more comfortable—but just how many clos are required is not yet known. A new space-age word, "clo" is the quantity of clothing that will maintain a comfortable heat balance for a man sitting at rest in a room with 70-deg temperature, 50 per cent humidity, and air movement of at least 20 feet per minute. Tailors to the spacecraft set are faced with problems of nonearthly reactions of the human skin in other atmospheres, unavailability of air-conditioning equipment, and lack of data on temperature conditions.

• • •

Big-league vending machines will accept paper money—and give change in either bills or coins. Universal Controls Inc. and Universal Match Co. have developed ticket-vending equipment that will recognize and accept either one or five-dollar bills. First application is to be for the sale of pari-mutuel tickets at race tracks; future systems will be made to handle railroad and bus tickets.

• • •

Forget the Christmas turkey? Don't fret, say the people who make Norge clothes dryers, if you neglected to defrost the bird—this job can be done by a dryer in a fraction of the normal 24 to 48 hours. A dryer whose tumbling can be turned off, set at low heat, will put a 15-lb turkey in roastable condition in about 3 hours.

• • •

What big teeth the patient seems to have when they are viewed with a new optical system developed by Avco Corp. for the Navy. The instrument has a bundle of 10,000 tiny optical fibers bound together in a cable with a lens at the probing end. A closed-circuit TV camera is attached to the other end. The "picture" that appears on the screen is magnified up to 35 times actual size. Further development of the probe is expected to permit viewing insides of other body cavities—highly magnified and in color.

• • •

Model of a World War IV weapon is on display in the Pentagon, courtesy of Herbert York, chief of defense research. It's a spear.

• • •

Do-it-yourself color coding of special wire used in electronic components can be done with a new system developed by Spectra-Strip Wire & Cable Corp., Garden Grove, Calif. Equipment taking up less than a cubic foot of space dyes any length of wire almost any color when and where it is needed. Even stripes can be produced on the wire's coating.

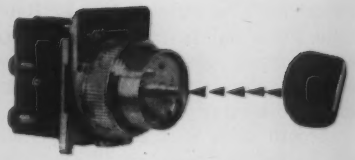
NEW COLOR-CODED CONTROL STATIONS

by Cutler-Hammer

Now Cutler-Hammer 10250T Oil-Tight Control Units permit color-coding of your machine control stations and operator panels. New selector switches feature interchangeable colored operating knobs that match the six distinctive colors of Cutler-Hammer's Oil-Tight Pushbuttons and Indicating Lights.

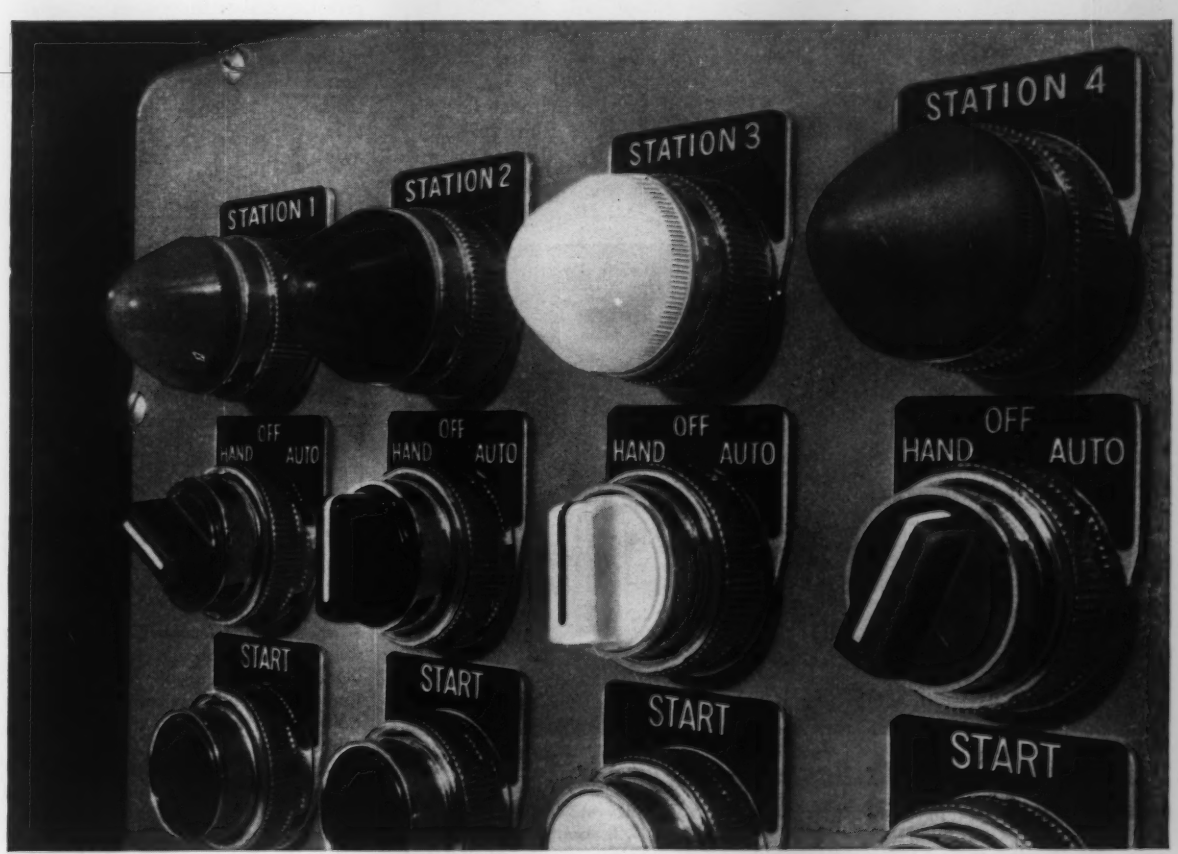
Color-coded control stations assure rapid identification of the individual control units minimizing the operator's chances for pushing the wrong button at the wrong time. Color-coded control stations also shorten the time required to train new personnel in the operation of your machines.

Check the control stations on your machines . . . be sure they are equipped with color-coded Cutler-Hammer 10250T Oil-Tight Control Units. They cost you nothing extra. Write today for the handy selection guide, Publication EL178-Z243. Cutler-Hammer Inc., Milwaukee 1, Wis.



Interchangeable operating knobs on the new Cutler-Hammer Oil-Tight Selector Switches match the six distinctive colors of the 10250T Pushbuttons and Indicating Lights. A single set screw assures quick assembly. Mounts in any position, too.

• RED • BLACK • GREEN
• YELLOW • GRAY • WHITE



CUTLER-HAMMER CONTROL

CUTLER-HAMMER

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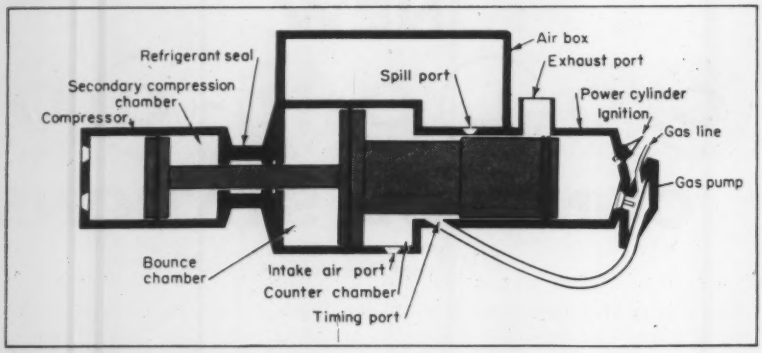
Gas-Fueled Compressor Developed for Air Conditioning

Bounce-Piston Cycle Proves Efficient and Quiet

COLUMBUS, OHIO—Residential cooling by gas may be just around the corner. A research and development program, sponsored by the American Gas Association at Battelle Memorial Institute, has led to a practical gas-fired, free-piston compressor able to drive a home-size air-conditioning unit.

According to R. J. McCrory, chief of Battelle's Mechanical Research Div., the free-piston configuration has an inherent simplicity which makes possible low initial cost and long service life. Although there are intake and exhaust noises, the compressor is currently operating at reasonable noise levels with commercially available silencers.

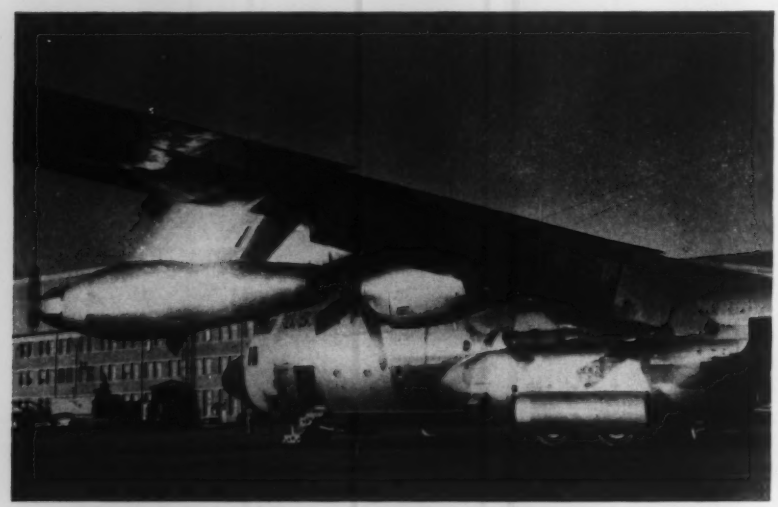
The unit operates at a design speed of 1500 cycles per minute to produce three tons of refrigeration (36,000 Btu per hr) with an overall efficiency of 75 per cent (heat input converted to useful cooling).



The free-piston machine is a simple spring-mass system, say Battelle scientists. Because there are no mechanical connections to the piston, its motion is a function of the gas forces imposed by the various chambers. Energy is transferred between working chambers by the piston's kinetic energy rather than by direct transfer of force. Operating speed depends on both the piston mass and the effective spring rate of the combined gas forces.

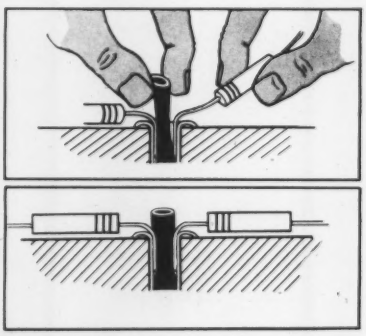
To start the cycle, the piston is drawn down to its lower limit. At this point the gas pump contains a full charge and the power cylinder is filled with air. On the starting stroke, refrigerant forces the piston up, and after the exhaust ports are covered, the pump injects fuel into the power cylinder (which already contains combustion air). Ignition occurs near the top of the stroke. After ignition pressures have forced the piston down (compressing the refrigerant), exhaust and inlet ports open and refrigerant pressure drives the piston up again.

Exclusive license to make and market the compressor has been assigned to Robertshaw-Fulton Controls Co., which will sell the unit to any air-conditioning equipment manufacturer who wants it.



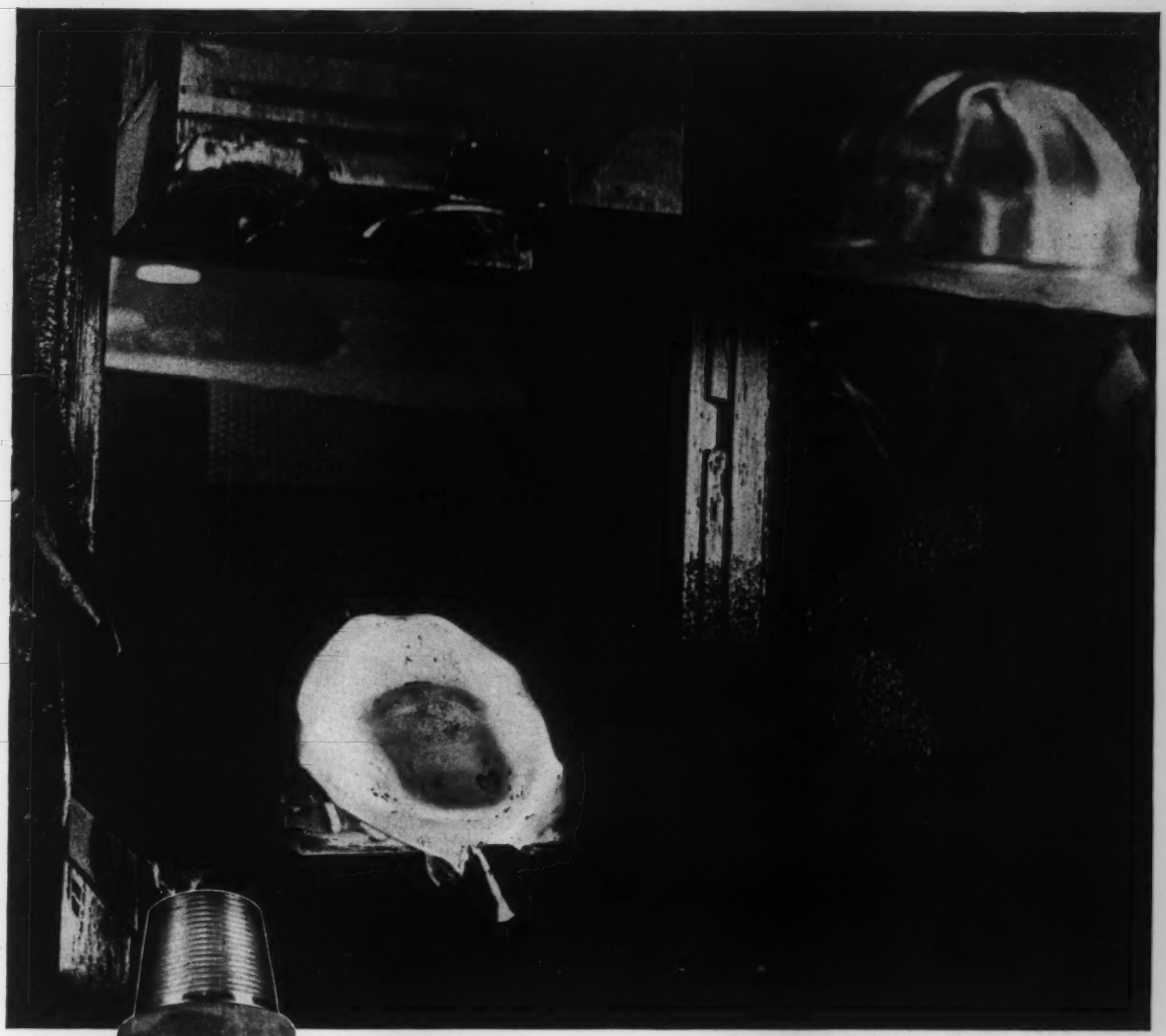
Jets Supply Propjet's Boundary-Layer Air

Exceptional short-field performance is expected from this version of Lockheed's C-130 transport; it's being readied for the first flight with boundary-layer control. The turbine-powered giant (four Allison T-56 engines supply 16,200 hp) carries two turbojet engines slung under the wings to supply high-pressure boundary-layer air. This will be blown over wing and tail surfaces via ductwork in wings and fuselage. Landing roll of the craft is expected to be no more than 460 ft—a good average for light planes. Flaps (above) are set at 90 deg, the position for sharp takeoffs and landings.

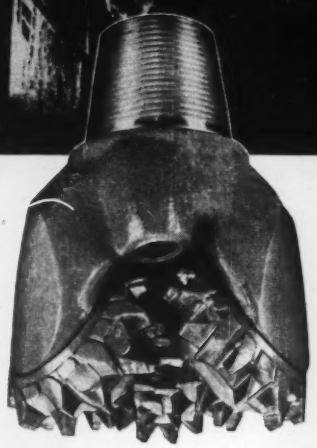


Connections Are a Snap

Fast, solderless connections between wires and component leads are provided by a new rubber and gold junction cell. The device consists of a gold-plated eylet and a long-wearing rubber core. When the resilient core is pulled upward, wires are easily slipped inside the eylet to be held firmly in place when the core is released. Gold-plated surface of the eylet establishes an electrical contact of virtually zero resistance. Developed by Plastic Associates, Laguna Beach, Calif., the connector is immune to shock and vibration and accepts multiple wires with different diameters.



Photograph courtesy of Pacific Forge, Inc., Fontana, Calif.



Of course Pacific Forge is fussy about surface condition

On drill bits for Security Engineering Division, Dresser Operations, Inc., Aristoloy round-cornered squares meet this forger's stringent requirements. In-plant scarfing and grinding prior to forging have been eliminated—rejects caused by surface defects have been reduced to a minimum.

The secret—careful control of Aristoloy Steels from electric furnace melting to final rolling operations. The result—alloy steels of prime forging quality—and uniform chemical, structural, and hardenability characteristics that satisfy the critical use requirements for rock drill bits.

For complete information about Aristoloy structural alloy, stainless and carbon steels in leaded or standard analyses, contact the local Copperweld representative in your nearest large city. Or write for complete information.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

Circle 409 on Page 19

Teflon-Surfaced Ways Cut 60 per cent from Table-Traverse Friction

FIGHTING FRICTION with Teflon—a well-established tactic in design at large—is now beginning to show results in the machine-tool business. The DoAll Co., Savage, Minn., reports that it's successfully using Teflon-surfaced ways on a line of manual grinders (specifically, Model DH-612). Results are impressive: Table friction forces are reduced more than 60 per cent (from 12 lb down to 4 lb); machine accuracy is found to actually *improve* with service; and damping properties of the Teflon are credited with upgrading quality of surface finishes imparted by the grinder.

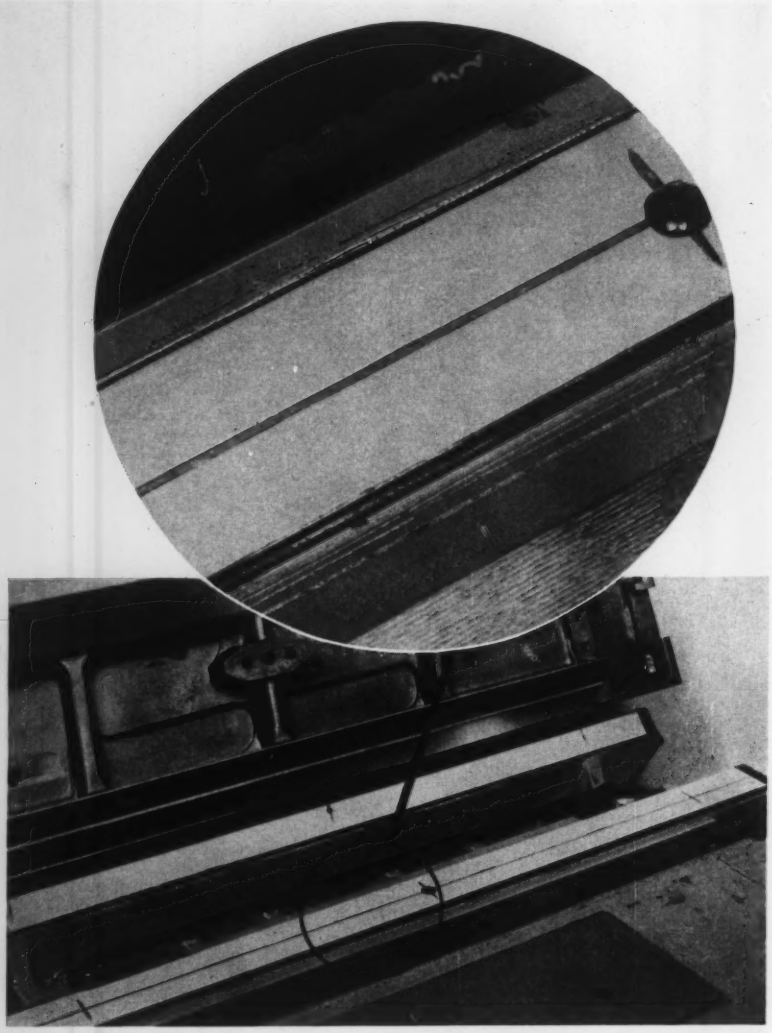
DoAll has licked Teflon's cold-flow tendencies (a problem with thick sections) by applying it to grinder ways in thin, specially processed strips. (Teflon thickness is uniform throughout; one side is treated to allow bonding to the ways with an epoxy adhesive.) Saddle ways are prepared in the usual fashion, except that flaking and oil grooves are not required. After being cemented to the ways, the Teflon layers are oil grooved. Developers emphasize that the only purpose of the oil is to flush dirt out of the ways, *not* to provide lubrication.

Satisfied that Teflon met the primary design goal (reduced table force), DoAll also checked its all-around suitability for a precision-grinder application. Laboratory and field tests showed no undesirable cold flow or other plastic deformation, and no indication of aging. As an extreme heat test, hot water—circulated through the grinder coolant system—was used to hold the Teflon bearing surfaces at 180 F for a 48-hr period. This was done with the table (plus 300-lb load) at one end of its stroke. At the conclusion of the test, ways were examined for evidences of plastic deformation. None could be found.

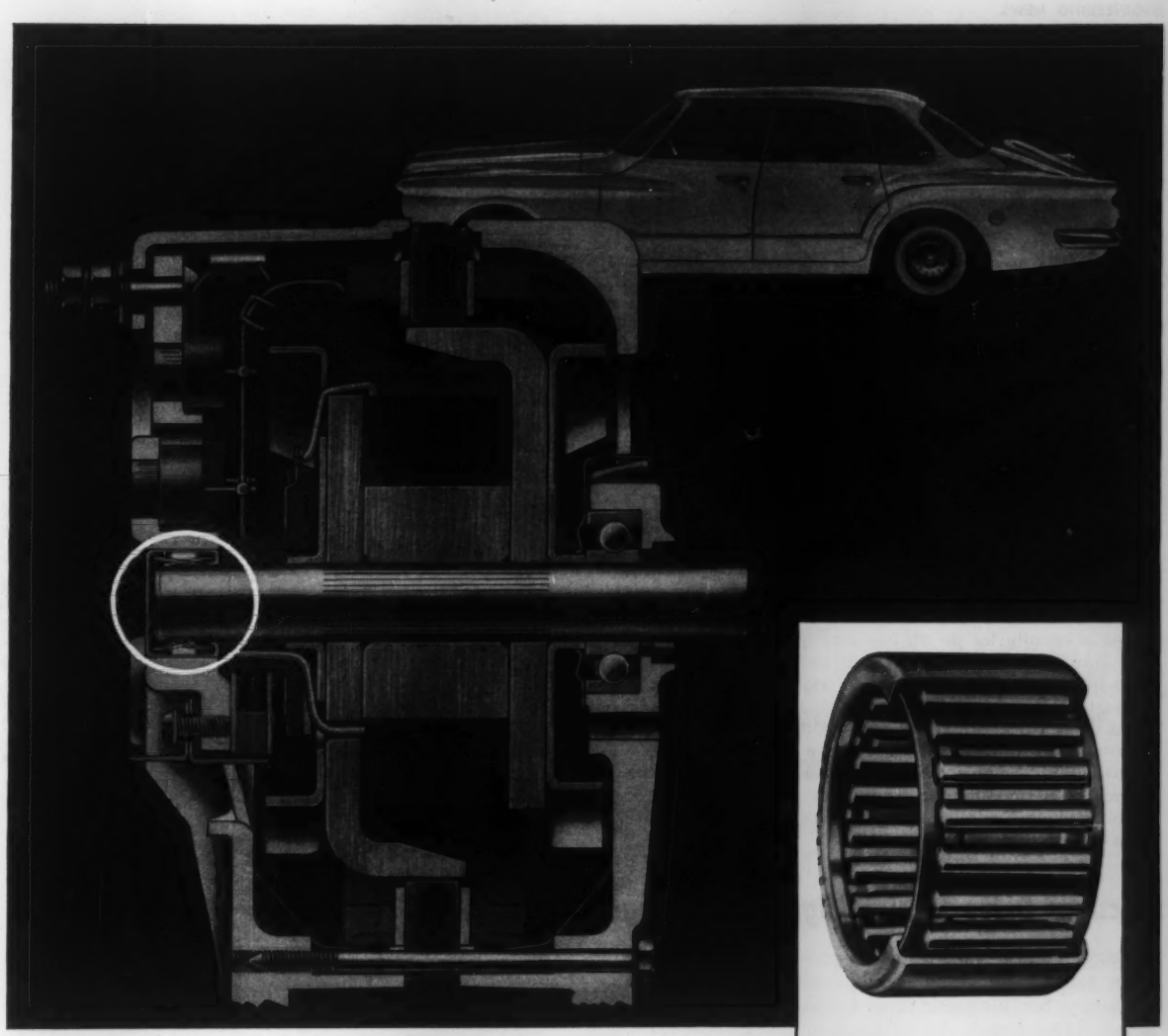
To test Teflon-way durability under prolonged exposure to poor maintenance, DoAll blew abrasive dust (from floor sweepings) between table and saddle. The machine was operated until friction increased prohibitively (after about 30 hr). When ways were cleaned of abrasive particles, coefficient of friction was found to have returned to its original low level.

Fringe benefit for the Teflon-way installation is a progressive wearing-in action that occurs with continued use. In general, grinder accuracy is found to improve up to approximately the 1000-hr point, remains constant thereafter. Should ways eventually need refacing, DoAll says the Teflon can be stripped off on the job and replaced without special techniques or equipment.

Teflon ways are optional on DoAll's DH-612 surface grinders. Because they reduce the effort required to move the table-feed handwheel, the ways are recommended wherever the additional cost of a hydraulic table-traverse attachment is not justifiable. According to developers, Teflon ways can easily be installed on existing machines.



Teflon rubbing surfaces, bonded to saddle ways in thin strips, greatly reduce friction forces (and operator effort) required to move the table of this DoAll surface grinder. Developers found that Teflon-surfaced ways were not only more accurate than the cast-iron base ways on which they're mounted, but they wear-in progressively—giving more machine accuracy after 1000 hr than when first put into service. Use of Teflon in thin-strip form minimizes cold-flow tendencies, permits easy replacement in the field without special equipment.



Armature-mounted Torrington Drawn Cup Roller Bearings offer these outstanding advantages:

- Highly efficient roller guidance
- Ample provision for lubricant storage and circulation
- High capacity in small cross section
- Long pre-greased service life
- Outstanding efficiency at high speeds
- Easy mounting by press fit
- Simple housing design
- Low unit cost

Torrington Drawn Cup Roller Bearings Used in Valiant's Alternator

Compactness, efficiency, economy, reliability . . . these are outstanding features of Chrysler Corporation's exciting new small car . . . and of Torrington Drawn Cup Roller Bearings. Used by Chrysler in the Valiant's new alternator system for electrical power generation, these bearings provide smooth, trouble-free operation and long service life without need for relubrication.

Torrington Drawn Cup Roller Bearings offer performance advantages in all types of generators and appliance motors. The cost is remarkably low . . . in many cases, armature bearing costs have been lowered by as much as 50%. For advice on the application of Torrington Drawn Cup Roller Bearings to your specific problems, call or write: **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TORRINGTON BEARINGS

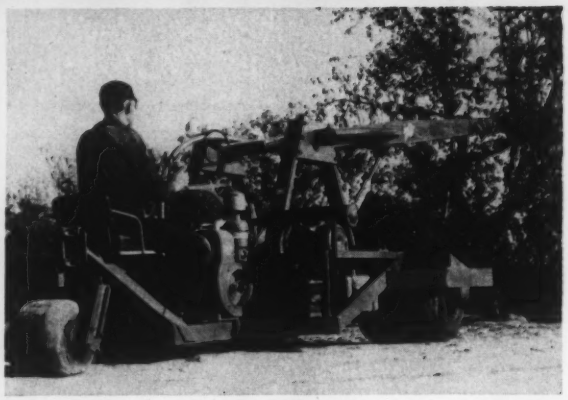
Every Basic Type of Anti-friction Bearing

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

Circle 410 on Page 19

Soft Touch for Sensitive Terrain

Mobility for a variety of off-highway vehicles is provided by a selection of oversize tires that can be tailored to both the vehicle and the expected ground conditions. Properly applied, the tires carry their design load without breaking ground surface and leave an almost indistinguishable track. Designed originally for an off-highway missile carrier, by Goodyear Tire & Rubber Co., the Terra Tires now appear on everything from aircraft to tree knockers (right). In the latter application (shaking nuts off pecan trees), the tires' soft, bald surfaces don't crack grounded nuts. Other applications include a furrowless racetrack smoother (above right) and a lazy man's light-treading golfing companion (the tires barely ruffle the surface of a smooth sand trap). For complete design details on off-highway mobility, see the article by M. G. Bekker on page 92 of this issue.



Vacuum Drive Babies High-Speed Magnetic Tape

BOSTON—A new vacuum drive provides a much-improved standard of efficiency for magnetic-tape transports. Developed by Datamatic Div., Minneapolis-Honeywell Regulator Co., the drive is reported to increase both tape life and speed of information transfer. The unit was designed for the new M-H 800 high-speed data processing system now being readied for production.

The tape transport reads or records information at the rate of 96,000 decimal digits or 64,000 alpha-numeric characters per second. When several of the transport units are coupled to supply or receive information, information transfer speed is the highest of any available with commercial data-processing systems.

The all-vacuum drive (clutch) and the use of vacuum to hold both the tape reel on its hub and the tape on the reel are said to provide the most gentle tape handling yet achieved. Magnetic tape damage is

All-vacuum drive developed for magnetic tape transport treats the tape so gently that its life is expected to increase substantially. Higher safe drive speeds are now possible. They permit 96,000 decimal digits per second to be recorded or read by the new Honeywell 800 computer, the first unit to use the new drive.

expected to be virtually eliminated, and tape life should be substantially increased.

The mechanism can accept start and stop commands arbitrarily close together without involving the tape in a tug-of-war between powerful clamps. Operational requirements for 180 start-stops per second can be handled.

The tape, driven at a speed of 120 ips in either direction, responds almost instantaneously to commands. It starts to move in less than one millisecond after receipt of a command, and in 2.7 milliseconds it is traveling at full speed. When ordered to stop, it decelerates in less than 0.3 inches.

Built-in Management Training Comes with Engineering Degree

ATLANTIC CITY, N. J.—An engineering education provides the best basic training for executive positions, according to O. S. Carliss, director of engineering, Yale and Towne Mfg. Co. Speaking at the annual meeting of the American Society of Mechanical Engineers, Mr. Carliss observed that many of today's management decisions are technological, and efficient use of the results of basic scientific data requires men of vision who also understand and appreciate these data.

"The problem of the manager is to obtain group success in a field where the individual and his contributions are paramount." The best way to develop the executive judgment, foresight, and objectivity to bring this about is through an engineering education, says Mr. Carliss. The study of science, which is an integral part of an engineering education, and the basic humanities background which an engineering school provides, give the prospective manager a start in knowledge of people, and communicating with them, and in the discipline of thought necessary to plan and complete projects.

"It is my firm conviction," he concluded, "that in a world where scientific achievements exceed the wildest imaginings, the engineering school provides young men with the wealth of experience they need to manage—for the best use of mankind—developments yet to come."

Hub assembly with integral preloaded duplex ball bearing, used in electronic missile system developed by Westinghouse Air Arm.

"IN-BORN" BEARING IN HUB ASSEMBLY

Gives Better Accuracy, Weight and Cost

Important advantages can often be gained by "designing in" bearings as a part of the unit in which they operate. A case in point is this hub assembly, produced and bearing-engineered by ITI.

Here, the two outer raceways and one inner raceway are formed in the hub and shaft; and the second inner ring — made separate to permit assembly — is close to a zero-tolerance fit. Compared to the usual design (using separate bearings), this construction gives (1) higher and more uniform accuracy, through elimination of 6 radial tolerances; (2) less weight and greater compactness, by eliminating 3 rings; and (3) lower total cost.

Other features include low running torque, labyrinth seals, high vibration resistance, and a dished hub held within .001" of the mathematically-specified contour.

In comparable ways, you too can benefit through our ability to design and produce bearings having unusual compactness or configuration, heat resistance, corrosion resistance, ultra precision, or other special properties. Let's talk it over.

FREE BULLETIN AFB-2 tells about the factors involved in special bearing applications, describes our work in this field, and shows a wide variety of special bearings. Write for it!

INDUSTRIAL TECTONICS, Inc.

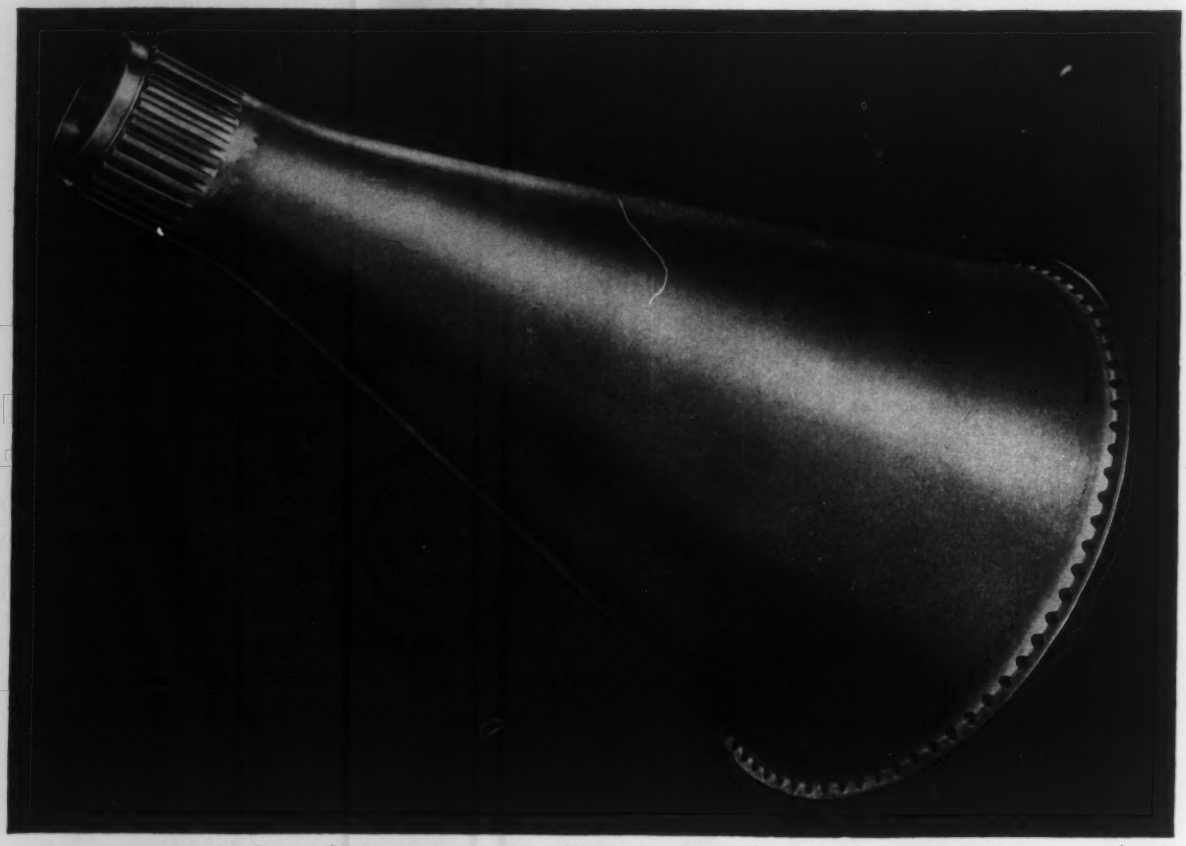
ITI

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3682 JACKSON RD., ANN ARBOR, MICH.

WESTERN DIVISION PLANT: COMPTON, CALIFORNIA

Metallurgical Memo from General Electric



René 41 conical forging is 30" high, 26" O.D. at flange; forged from 510-lb. billet multiple. Offers tensile strength of over 100,000 psi at 1650° F.

How René 41* combines WORKABILITY with top strength at high temperatures

Metallurgical Products Department reports on a new vacuum-melted super alloy—and on how its unique properties make it ideal for use in everything from jets to machine components

When design specifications call for the "impossible"—*workability* combined with top strength, minimum weight, and high temperature resistance—a G-E vacuum-melted alloy may be the answer.

For example, this front conical turbine shaft for a jet engine is made as a forged, backward extrusion—requiring excellent workability. And, because of the part it plays in the functioning of the engine, high strength and resistance to supersonic temperatures (1000°-1800° F.) are musts! The solution: René 41 alloy!

Virtually free from impurities, René 41 can be successfully forged, welded, or formed; offers top tensile and stress rupture strengths, increased ductility, operational reliability. With these unique properties, René 41 is well suited to applications in machine design, as well as in jet engine components!

Got a design problem? Choose from General Electric's variety of high-purity, vacuum-induction-melted alloys in sheets, bars, billets, wire, or castings. For detailed information—or the assistance of one of our engineers—write today to: *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile St., Detroit 32, Michigan.* *René 41 is a trademark of the General Electric Company.

METALLURGICAL PRODUCTS DEPARTMENT

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EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
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427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
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406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
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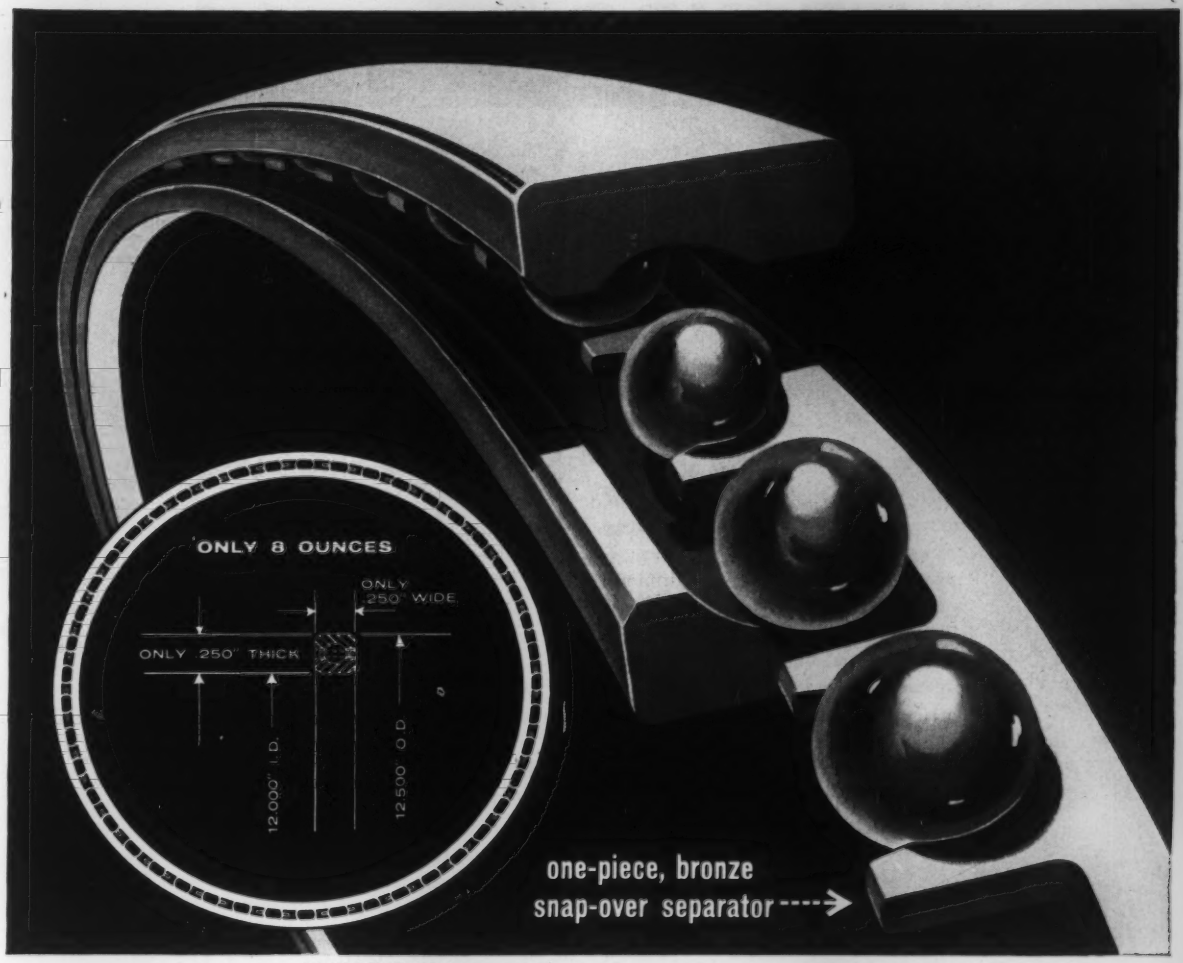


News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

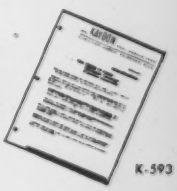
Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

Save on bearing cross-section and weight — Reali-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

Type "CP" with new one-piece, bronze snap-over separator — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical thin-section bearing applications.

New "CP" Reali-Slim bearing bulletin includes prices — gives you full details on these 90 sizes of Reali-Slim bearings with Conrad deep-groove, ball-radial construction. Write for your free copy today.



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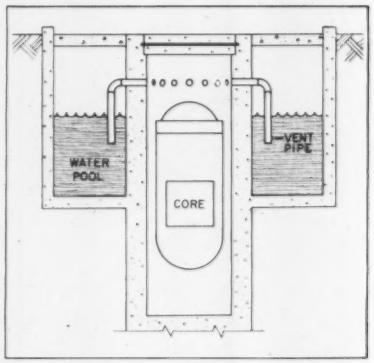
steam trap for runaway reactors



Although possibility of a serious power-reactor accident is considered remote, nuclear powerplant designers usually hedge against system failure by enclosing the reactor in a sealed safety vessel. Such outsized spheres and cylinders are built to withstand the pressures of water-cooled reactor explosions and to stop the spread of radioactive steam. They may soon be outdated by a new "pressure suppression" containment under development by General Electric Co. and Pacific Gas & Electric Co. engineers. Safer and less expensive than older containments, the new system surrounds the reactor with a dry enclosure and, if the reactor ruptures, vents over-pressures and "hot" steam to an adjacent water-filled pool. The water condenses the steam and absorbs any stray fission products. If AEC approves, PG & E's Humboldt Bay plant (Eureka, Calif.) will use a below-ground-level installation.

UK designers announce radical lube system

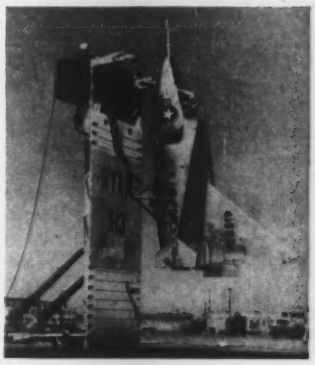
Conventional methods don't really work well when you are lubricating crankshaft bearings of internal combustion engines. That's the opinion held by researchers at Glacier Metal Co. Ltd., England. Their work has led to a development called Ramrod—a new lubrication system which, they claim, will let engine designers shorten bearings, stiffen crankshafts, and raise engine speeds. Company spokesmen call it the most dramatic advance in engine lubrication since the invention of the full-pressure system and say it will lead to more power from less bulk. Ramrod will be introduced in the U. S. early next year.

the spread of adhesives

As recently as 1939, no metal-to-metal adhesive-bonded structures were produced commercially; today, airplane fuselages, truck trailers, even parts of buildings are glued together, and application in missiles is being considered. Newest developments were discussed at an ASTM symposium on adhesion and adhesives. They include German adhesives that cure at room temperature—notable because most work in the U. S. has been with heat-curing types. A sticky problem with the widely used phenolic or epoxy-modified phenolic types of adhesives is that they can take only short exposure to high (500 to 1000 F) temperatures. Narmco Industries Inc. is adding inorganic components to organic adhesives to provide thermal resistance. Ceramic adhesives, prepared as frits and applied to stainless steel, are being tested by Hughes Aircraft Co. for wings and control surfaces of missiles. Data from tests at 800 and 1200 F are promising.

Air Force plans competition for new VTOL contract

Last manned combat aircraft ordered by the Air Force will probably be a supersonic VTOL. Preliminary arrangements are being drawn up for a design competition among American manufacturers. Funds for evaluation of proposals are available and the contract will probably be assigned and financed during fiscal 1961. Winner of the competition will supply stripped-down VTOL prototypes that are able to fly faster than present fighters, i.e., faster than 1400-1500 mph. Design entries are expected from Northrop, Convair, Bell, McDonnell, and Republic.



putting the hex on square-head bolts and nuts

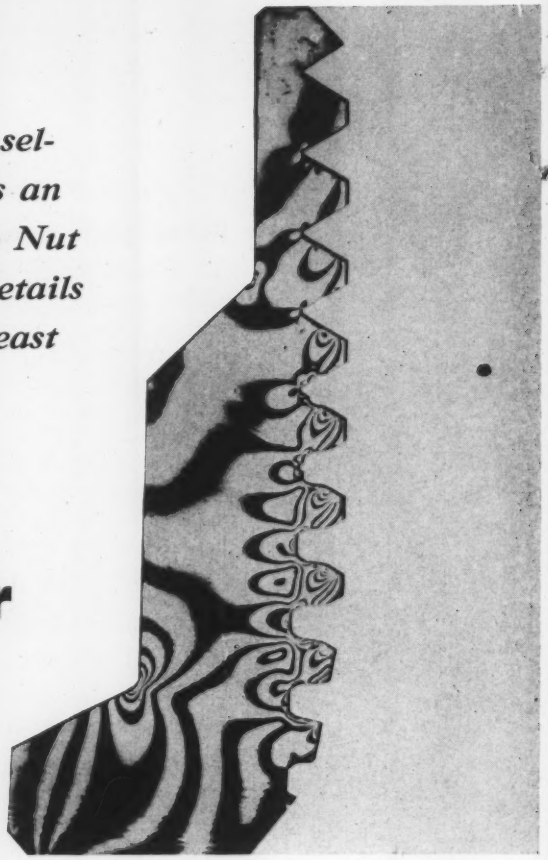
Making hexagon heads standard on bolts and nuts would benefit the national economy, according to William G. Waltermire, chief product engineer of Lamson and Sessions Co., Cleveland. Speaking at the recent Industrial Fastener Applications Institute held at the University of Wisconsin, Mr. Waltermire observed, "Hand assembly with open-end wrenches is disappearing; with socket wrenches and power drivers, a hexagon shape may be adequately tightened, and—as compared to a square shape of the same across-flats dimension—the hexagon shape decreases the diameter of the driving socket . . . makes it easier for the socket to engage the bolt and nut surfaces." A hexagonal shape is more economical to manufacture; standard heads would, of course, simplify tool requirements.

new NBS tools will calibrate big forces

Final designs for dead-weight machines with 300,000 and 1 million-pound capacities have been drawn up by the National Bureau of Standards. They'll be used to calibrate primary and secondary standards for measuring large forces. Until now, the Bureau has been getting along (since 1931) with a 111,000-lb tester; larger forces have been measured indirectly or on a less accurate machine. Industrial weighing now requires accuracies of 0.05 to 0.2 per cent, and accuracies of 0.1 per cent or better are needed for measuring thrusts of large rocket engines. Weights used in the new machines are expected to be accurate within 0.005 per cent.

Threaded fasteners (nuts and bolts) seldom make exciting news. But here's an exception. Designers at Elastic Stop Nut Corp. of America have just released details of a new thread form that will at least

Double Fatigue Life for Threaded Fasteners

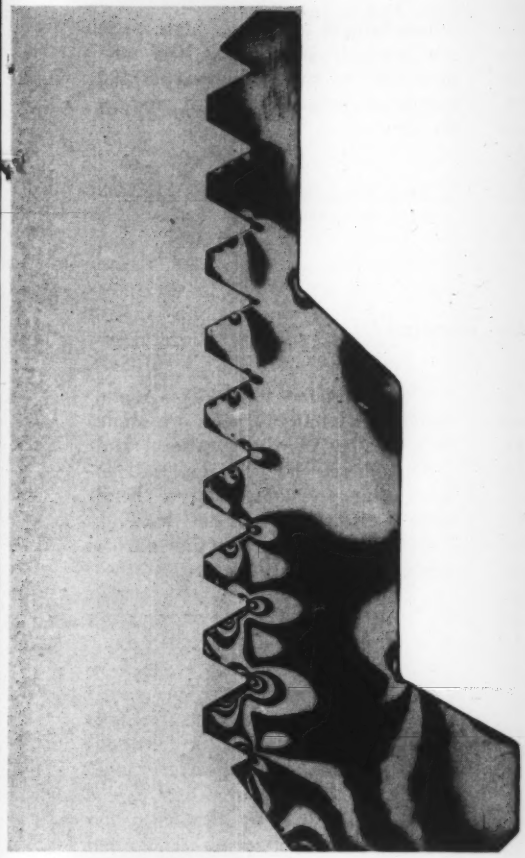


IT'S THE NUT, not the bolt that is largely responsible for fatigue failures in high-tensile nut-bolt combinations . . . and this engineering fact of life is goading fastener designers into making significant changes in the status quo. By perfecting a new thread form for nuts, engineers at Elastic Stop Nut Corp. of America, Union, N. J., have more than doubled the life expectancy of high-tensile, self-locking, nut-bolt combinations. What's more, the new thread form is not a radical departure from the norm; it can still be inspected with conventional techniques and standard gages.

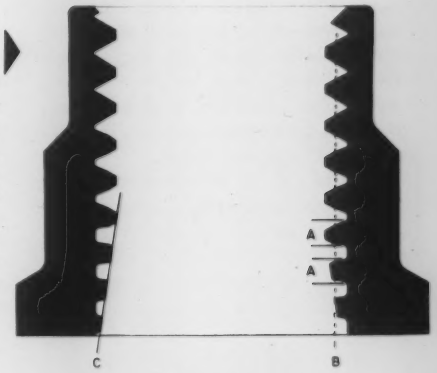
To take immediate advantage of this significant development, ESNA has selected a series of lightweight, high-tensile nut designs which have proved their reliability in millions of aircraft applications. Modified to incorporate the new thread form and tagged with the name Double/Durability, the nuts have been put through hundreds of fatigue tests. Here's a summary of their performance:

"The average endurance of all bolts tested in fatigue with the new nuts was 4½ times greater than bolts tested with standard nuts. More significantly, none of the bolts tested provided less than double the fatigue life of the equivalent standard bolt; fatigue life was multiplied from more than 2 to as high as 12 times."

To the designer, the new fasteners offer immediate possibilities of



Photoelastic comparison of stress distributions between EBT nut with the new ESNA thread form (left) and standard type EB nut (right) shows a significant difference in load-carrying properties. Most of the load, carried by only three threads in the standard nut, is effectively redistributed over six threads in the modified nut.



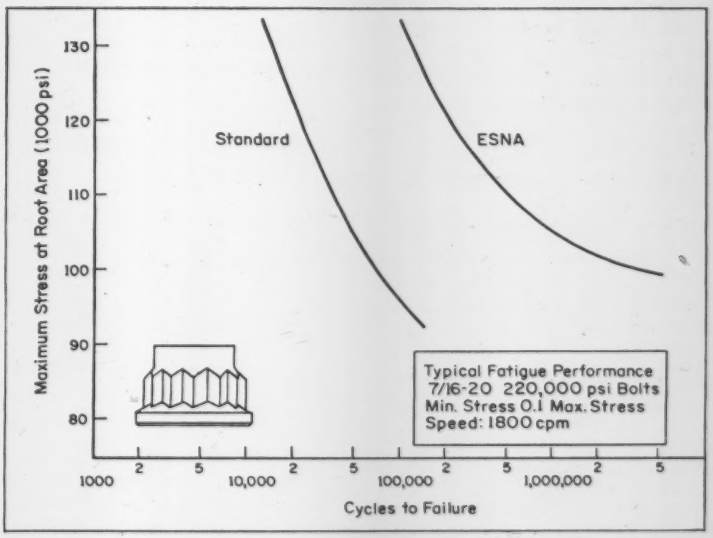
Two "big" changes in nut design reduce high load concentration on the first engaged thread: 1. Bases (A) of each of the threads in the lower part of the nut are reduced (width of the roots is increased). This permits these threads to deflect a greater amount, thereby overcoming to some extent the decrease in pitch that normally occurs. The deflection redistributes the load so that a smaller part of the load is transmitted to the bolt by the lower nut threads. Maximum pressure on each thread occurs near the pitch diameter (B). Since the new thread has a standard pitch diameter, the load is still carried at the same radial location. 2. In addition to the standard countersink, a special countersink is used (C). This increases the minor, or crest, diameter of the lower nut threads, and provides a gradual effective increase in pitch of the nut threads, to accommodate pitch growth in bolt threads.

product simplification. In existing applications, for example:

- Reliability under fatigue conditions is greatly improved without affecting interchangeability of existing parts.
- Maintenance procedures, where strict "retightening" is prescribed (accompanied by unfavorable time and cost elements) can either be eliminated or drastically reduced.
- Weight of the existing component may be cut substantially by the use of low-profile nuts and shorter thread-length bolts.

In the case of new designs, fatigue control of fasteners can be tackled from an entirely fresh viewpoint:

- It is possible to use fewer bolts



The bolt is the benefactor of a new nut design, as shown by these fatigue-test results. Typical high-tensile bolt with a standard nut gets new life when fitted with the ESNA-threaded nut.

and nuts to carry the same load.

• It is possible to use the same number of bolts, but of smaller size.

Where multiple bolting might normally be standard procedure—for reliability reasons—a very few large bolted connections may now be relied upon to carry the load. For highly critical connections where fatigue loading is high, or is not precisely determined, the new nuts can be specified as a positive means of assuring a high margin of safety.

Primer on bolt fatigue, or Why Hold the Load with One Thread?

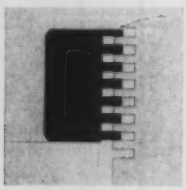
Fatigue failure, according to the book, is a progressive phenomenon that develops at a point of maximum tensile stress. Its beginning: An incipient crack at the surface that grows (at right angles to the direction of tensile stresses) by the action of repeated loads.

Fatigue of a threaded connection almost invariably occurs at the outermost surface of the first bolt thread that is engaged with the nut.

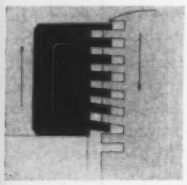
As photoelastic studies show—

a mating bolt and nut, with conventional threads in uniform contact before loading, will in the process of loading, shift almost all the load to the lower threads. Since failure invariably occurs at the first engaged thread, additional tensile stresses other than the pure axial stress in the bolt must be responsible. Starting at this point, engineers at Elastic Stop Nut Corp. followed a logical route to the selection of a new thread form.

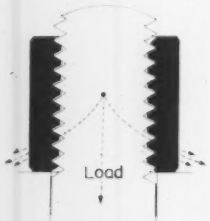
Threads on both nut and bolt can be considered as stubby cantilevers acting against one another.



It is believed that the center of pressure of individual thread loads occurs at or near the pitch diameter. If this load is a maximum at the first engaged threads, these will be deflected most. However, in deflecting, the first thread will transfer some of the load to the second thread, which, in turn, will deflect. This action brings about a gradual transfer of at least a differential load throughout the engaged threads of both nut and bolt.

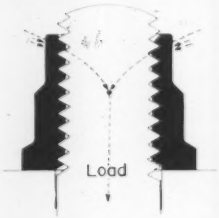


Because the nut is under compression, some circumferential stretching of the base will occur. Many types of high-tensile nuts provide a base ring to compensate for the compressive load at the base of the nut. Even with these designs, however, some measurable stretching occurs, which effectively expands the base of the nut where the load is greatest.



Stretching provides for some unloading of both bolt and nut threads—an effect also gained by tapering the threads—and the first threads are relieved somewhat. The basic effect is to change the pitch-to-lead relationship.

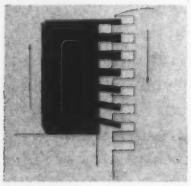
Nuts intended for use on high-tensile, high-fatigue bolts are made in a number of configurations, and it is common for the nut wall to have some elasticity and to bend under effect of external loading. Generally, the top of the nut is more flexible than the base.



Bending is also similar to tapering of the threads and is related to base expansion. In any event, it tends to unload the lower threads and to provide for a more nearly uniform load distribution than would be predicted on theoretical grounds alone.

But bending of the bolt threads, namely the first engaged thread (where axial tensile stress is the highest) must be the guilty factor in bolt fatigue. And since the nut is responsible for both thread bending and for concentrating stress at the first bolt thread, it is logical to assume that nuts need improving.

This is precisely what designers at Elastic Stop Nut Corp. decided and arrived at this idea . . .



a nut with flexible threads—which relieves the bolt threads of most bending stresses.

ASME Honors Seven At Annual Meeting

ATLANTIC CITY, N. J.—Seven contributors to engineering were recognized by the American Society of Mechanical Engineers at their recent annual meeting. Six of the seven awards presented were traditional honors the society has conferred annually. The seventh, the Machine Design Award, is new.

The Timoshenko Medal, for distinguished contributions in applied mechanics, went to Sir Richard V. Southwell, former rector of the Imperial College, London, England. Sir Richard was cited "for teaching and research in the application of mathematical and numerical techniques to the solution of practical problems in engineering science."

The Machine Design Award, the new award, was won by Charles E. Crede, associate professor of mechanical engineering at California Institute of Technology. Professor Crede was described as "an inspired leader in the field of shock and vibration, who through eminent achievement by creative contributions in the research, development, and application of shock mounts, has advanced the field of machine design and furthered interest in shock and vibration control."

An expense-paid trip to the annual meeting was part of James S. Kishi's Old Guard Prize for his paper: "Boundary Layer Control by Suction Through Distributed Perforations." Mr. Kishi is currently a graduate student at the University of Texas.

The Melville Prize Medal, for the best original paper on a mechanical engineering subject by a Society member, went to Stephen J. Kline, associate professor of mechanical engineering at Stanford University. Professor Kline's paper was titled: "On the Nature of Stall." He has been a teacher at Stanford since 1952 and has supervised a number of projects in internal flow and thermodynamics.

Awards to university undergraduates went to Frederick Borjes (Newark College), James L. Benson (University of Vermont), and Rowe A. Ghirardini (Norwich University).

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Waterman representatives are in all principal cities. Write for Waterman Solenoid Valve Catalog No. 2000, and for Waterman Flow Regulator Catalog No. 1001.

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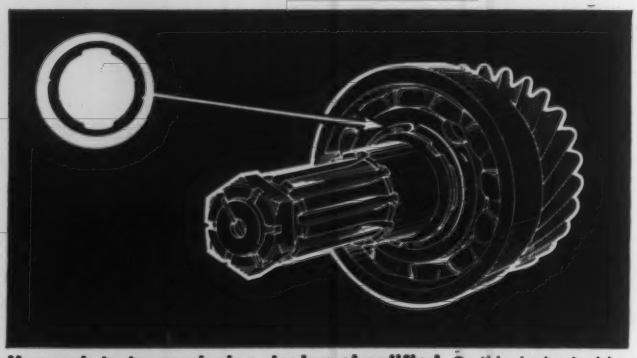

Heavy duty transmission design simplified. On this dual axle drive for trucks, a Truarc Series 5107 ring locks bearing on drive shaft. Interlocking ring design won't dislodge under heavy torque . . . is also recommended for high rpm. applications.

Designing with radially assembled Waldes Truarc retaining rings

solve varied product design problems—save machining, materials, parts and labor

Radially assembled retaining rings, which snap onto a shaft at right angles to its axis, greatly extend the range of products on which retaining rings may be used to simplify design and save parts or labor costs.

For example, rings for radial assembly can be used in applications where it is impossible to install a ring axially over the end of a shaft. Certain types are designed to accommodate shafts of relatively wide tolerances. Others described below may be used to provide a sizeable shoulder on a shaft.

The four applications shown here provide an indication of the wide range of products using radially assembled rings. The rings themselves are basic Truarc types each having specific design features. The high shoulder of one provides a large bearing surface on small diameter shafts; the low shoulder of another is ideal where clearance is limited. A third has an interlocking design which prevents it from being dislodged under torque or high rpm. A fourth can be used against rotating parts at the same time it provides spring tension.

These are but four of Truarc's fifty functionally different types of retaining rings with up to 97 sizes within a single type, six metal specifications and thirteen different finishes. Special hand, magazine, and semi-automatic applicators as well as grooving tools are also available to speed production. The entire line, together with over 70 typical applications, is described and illustrated in the new catalog RR10-58—yours for the asking. And call on us for design assistance on your specific project . . . a Waldes Truarc engineer will be glad to help. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y.

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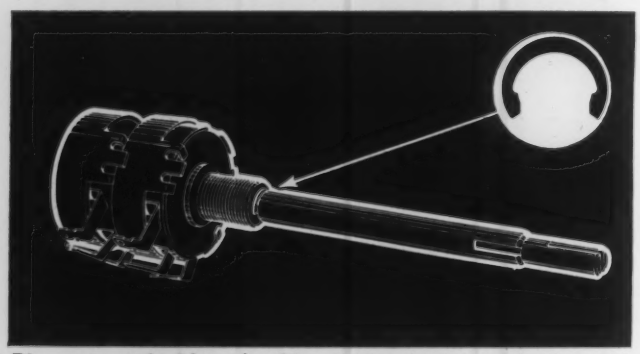
Rings replace machined shoulders, collars, set screws. That's what original design of this pneumatic temperature transmitter called for. Series 5139 Prong-Lock® ring with bowed design compensates for accumulated tolerances in parts, provides sufficient friction to prevent rotation under vibration. At the same time two Waldes E-rings position and lock adjustment screw to face plate.

Reinforced aluminum ring gives design advantages on louver windows. Waldes Truarc Series 5144 reinforced rings of aluminum secure hinge pins, eliminate costly riveting in linkage of louver type window. Ring design provides large bearing shoulder. Reinforced construction has 5 times the gripping strength of standard E-ring construction, allows use of non-corrosive aluminum.

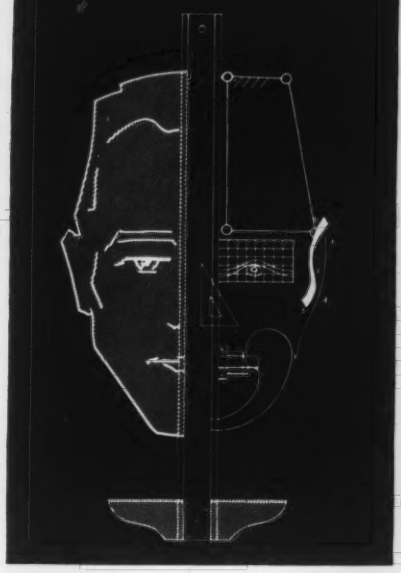


Ring acts as locking shoulder. Holding the threaded ferrule on this potentiometer shaft is a Truarc Series 5103 Crescent® ring. Crescent ring design with low shoulder provides ample clearance for assembly of panel locknut. It is less costly than a machined shoulder, more effective, quicker to install, easier to remove than the C washer previously used.

WALDES
TRUARC®
RETAINING RINGS
Waldes Kohinoor Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

Circle 415 on Page 19



The Engineer:

Paragon or Paradox?

Part 2 | His Intelligence and Abilities

Although the "norm" engineer is apparently not interested in people (Part 1), he is the guiding genius behind today's society. Call it intelligence, perseverance, or luck, the fact remains that no one else has done more to lighten the labors of man. But is he really intelligent, or is he some kind of supercraftsman? Here's a summary of major points of agreement among psychologists on this often-debated subject.

EUGENE RAUDSEPP
Research Consultant
Deutsch & Shea
New York

ALL STUDIES of intelligence have shown that engineers rank high. Superior mental ability is the outstanding characteristic of both the competent professional engineer and the successful engineering student.

On verbal intelligence, measured by the Wonderlic Personnel Test, only 10 per cent of the general population reached the mean of the engineers, and less than 4 per cent of engineers fell below the mean of the general population.

On vocabulary, measured by the Shipley Vocabulary Subtest, 8 per cent of the engineers scored less than the general population's mean, while again only 10 per cent of the general population measured up to the engineers' mean.

On reasoning, measured by the Shipley Institute Reasoning Test, only 6 per cent of the general population attained scores as high as the engineers' mean.

Excellent performance by engineers on the Otis Arithmetic Reasoning Test indicated definite superiority in this area also.

General Intellect: Findings Are Contradictory

Harrison, Tomblen, and Jackson ("Profile of the Mechanical Engineer") found that engineers fared no better on engineering aptitude tests than they did on tests which measured general intellectual ability. Furthermore, they performed almost as well on verbal tests as on tests with almost no verbal content. (This contradicts findings of several other studies to the effect that engineers are essentially nonverbalists and intellectually more capable along mechanical-spatial lines.)

Moore and Levy ("Artful Contrivers: A Study of Engineers") had this to say about engineers:

- All but one of the men in this group demonstrated superior or very superior intelligence—that one was estimated in the bright-normal range. . . . As a group, they have better capacity for dealing with

structural problems than with verbal ones; . . . Engineering does not penalize the man who is relatively awkward with words, so that their ability in this area covers a wide range from nearly "handicapped" to notably fluent.

In general, engineering training requires a high degree of general mental ability, and the lack of capacity for thinking abstractly and for dealing with higher forms of learning leads to professional failure.

Bright Students Take Engineering

There are, unfortunately, no data on intelligence distribution by occupational group. The Commission on Human Resources and Advanced Training, under the supervision of Dael Wolfle (in its study "America's Resources of Specialized Talent") resorted to the next best approach—checking from academic records the mental caliber of students who were preparing for careers in various fields. Wolfle reported marked differences in intelligence levels of students preparing for diverse occupations, and that these differences were notably similar to those found among college graduates employed in corresponding occupations.

A sample of over 50,000 students on various educational levels—high school juniors, college freshmen, college graduates, graduate students and recent recipients of Ph.Ds—were compared by the Commission. Results showed that students who achieved higher IQ scores seemed to gravitate toward occupations which require greater intelligence. This was found to be consistent on all educational levels.

Wolfle, in discussing his findings, wrote:

• In general, and at both undergraduate and graduate levels, fields which have the reputation of being "hard" get somewhat brighter groups of students than do fields which have the reputation of being easy. This is true whether one thinks of broad areas (for example, science ranks above education and commerce) or industrial fields (chemistry, mathematics, and physics average higher than do biology and geology). Thus the physical sciences, languages, engineering, and law are all fairly close to the top of the lists, while education, business, some of the social sciences, home economics, and physical education are close to the lower end.

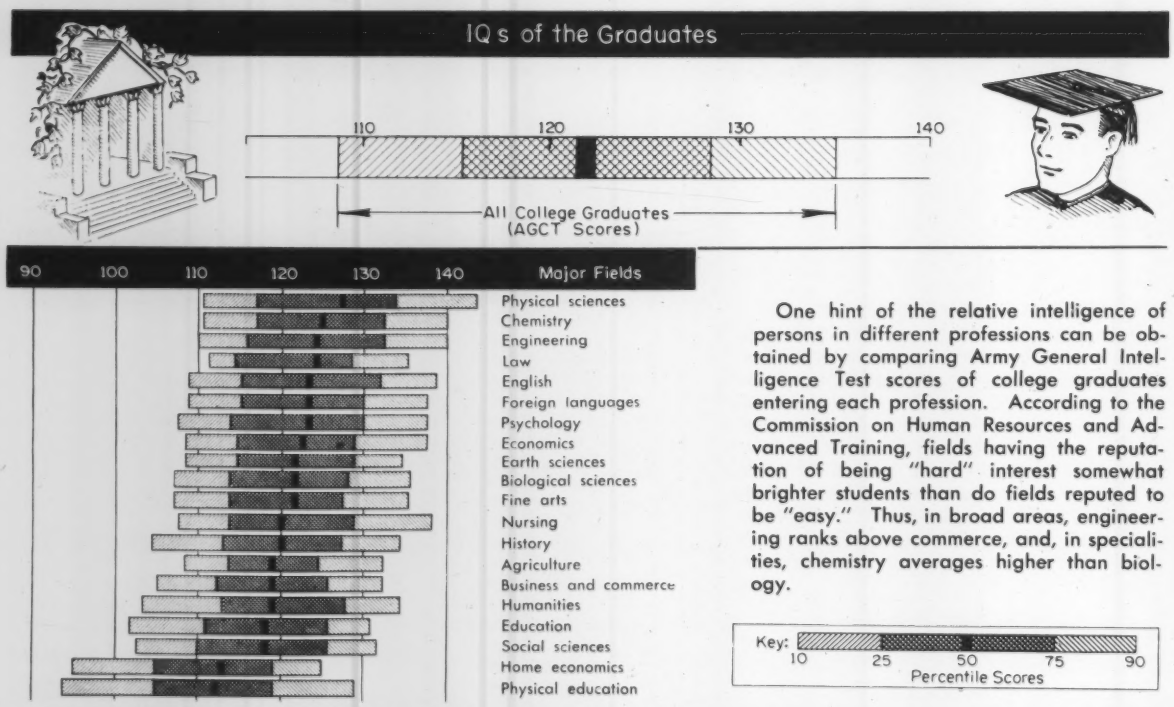
The Tipoff: High-School Grades

To make additional comparisons of students preparing for various occupations, the Commission utilized grades received in high school. Wolfle explained why he and his staff chose to ignore college academic records in this particular study:

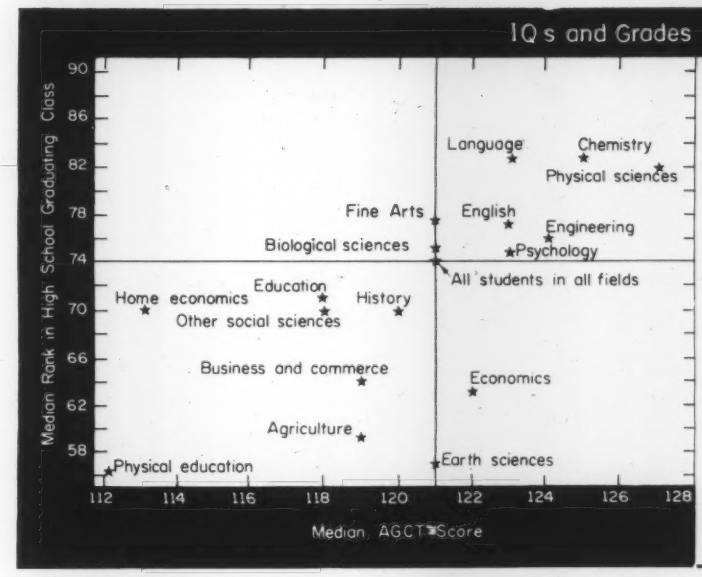
• It is of relatively little value to compare students in different fields of specialization in terms of their college grades, for most of those grades are not earned in the same or comparable courses. . . . In contrast, earlier in their school days all college graduates came through a more or less uniform high school curriculum. While he was in high school each college graduate attended classes and was in competition with students who later specialized in a variety of other fields. Their high school grades—despite their variability from one school to another—provide a more uniform standard than do college grades for comparing graduates in different fields.

Here is Wolfle's report on the results of his comparative study of high school grades:

• Students majoring in philosophy, chemistry, foreign languages, and physical sciences averaged the highest, having graduated from high school ahead of around 83 per cent of their classmates. A second group included graduates in the health fields, English, fine arts, engineering, biological sciences, and psychology. They



One hint of the relative intelligence of persons in different professions can be obtained by comparing Army General Intelligence Test scores of college graduates entering each profession. According to the Commission on Human Resources and Advanced Training, fields having the reputation of being "hard" interest somewhat brighter students than do fields reputed to be "easy." Thus, in broad areas, engineering ranks above commerce, and, in specialities, chemistry averages higher than biology.



What Jobs Get the Able People?

Grades earned in college are not a fair yardstick for comparing professionals in different fields. Some courses are harder than others. To correlate grades and intelligence, the Commission on Human Resources went back to high-school records of college graduates because high-school students all take about the same courses. Median class standing of the group was the 74th percentile, and median IQ was 121. Thus, the upper right quadrant of the chart shows potential engineers come from the most intelligent and most able members of the high-school classes.

finished high school ahead of about 77 per cent of their contemporaries. A third group included students of education, home economics, and all the social sciences except economics. This group earned high school grades above 70 per cent of their fellow students. Those in business and commerce and economics got better grades than nearly 64 per cent of their classmates. Students in agriculture, the earth sciences, and physical education had the poorest high school scholarship records, with average grades which put them above 57 per cent of their classmates.

Intelligence: Narrow Outside His Special Field

Studies show that the average engineer is highly intelligent. But, as we pointed out in the first article of this series, his intelligence is rather restricted, and, outside his particular field of specialization, quite unimaginative. His realism deals with surface values rather than with depths. He insists on highly structured phenomena and resents any type of ambiguity.

The engineer's performance on the Thematic Apperception Test pointed out his concrete-mindedness, and his tactical rather than strategical approach. Although well-organized, his stories were flat, prosaic, and unimaginative. This is just one more bit of proof that the engineer, in failing to develop certain areas of his personality, has paid the heavy price of overspecialization. The results of the TAT showed that he is incapable of sustained introspection, and that this makes for shallow and naive insight into himself and the people in his environment. As Harrison and his collaborators write:

• In a broader sense, engineers' human potentialities often go unfulfilled because of the disproportionate amount of time devoted to mechanical and impersonal activities at the expense of human relations. They also fail to study their own inner consciousness and to develop latent capacities for enriched and imaginative living. . . . Their impersonality and excessive control, combined with the conventionalization of their behavior, make many of them appear colorless and lacking in individuality. In the case of some of the more technically-minded men, one can go further and say that they are somewhat immature socially and emotionally.

Further evidence of the typical engineer's confined intelligence is provided by various studies which show that his range of interests is limited to the technical-mechanical on the one hand, and to the athletic-outdoor life on the other. There are very few indications that he is seriously interested in social sciences, human relations, public affairs, improvement of social conditions, fine arts, and other areas of culture.

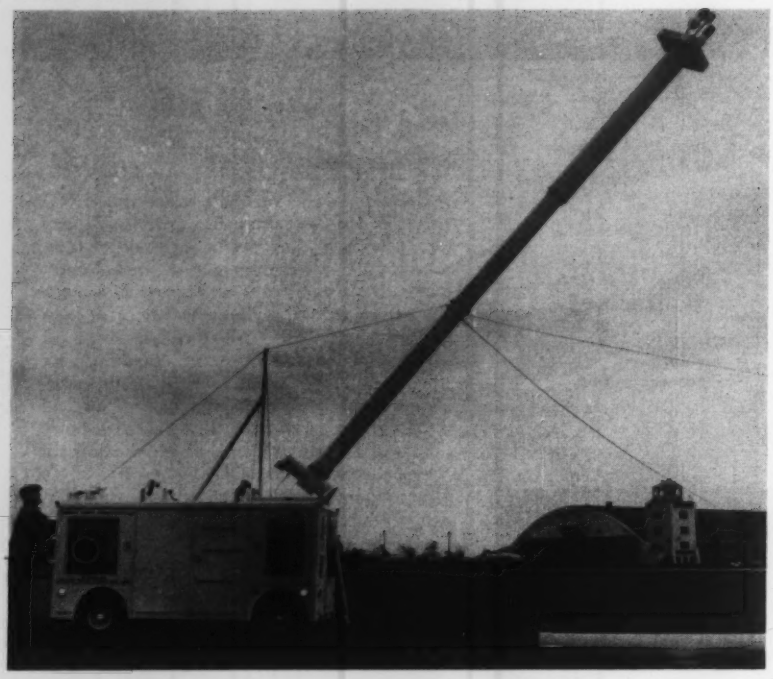
Long Suit: Mechanical Ability

On mechanical comprehension tests, engineers were compared to a group called "applicants for mechanical work." The intelligence level of this group was extremely close to that of the general population. It was found that less than 5 per cent of the engineers fell below the mean of the "applicant" group, and that only about 7 per cent of the mechanical applicants reached the mean of the engineers. Comparisons of test results for working engineers and freshmen engineering students showed the definite superiority of the professionals. Two explanations have been offered: 1. Engineering students of limited ability may be "screened out" during the four-year college course. 2. Mechanical comprehension increases with professional experience.

Surprisingly enough, on space relations tests, the superiority of the engineers was not as marked as it had been on tests of general ability. Approximately 15 per cent of the engineers fell below the mean of the general population. However, less than 26 per cent of the general population reached the average of the engineers.

A high degree of visualization is one of the primary requirements for satisfactory engineering achievement. For optimum professional performance, the engineer must display an excellent ability in the manipulation of spatial symbols and in the perception of sizes, shapes, and locations of geometric forms.

The third and final article in this series, in the January 7, 1960 issue of MACHINE DESIGN, will deal with the engineer's interests.



Electronic "Doctor" Diagnoses Fighter Ills

Fighter pilots will soon be giving their planes 60-second "electronic physical check-ups." Radfac (Radiating Facility for Aircraft Flight Line Testing), an electronic system developed by Republic Aviation Corp., speeds up pre-flight inspection of electronic gear in the F-105. Upon signal from the pilot (or crew chief) using a remote control unit, it checks the jet's communication, identification, and navigation systems. Verbal or tone signals tell the pilot whether the systems are in good working order and, if anything is amiss, Radfac pinpoints the trouble. Housed in a trailer, the system can be as far as two miles away and still function effectively. The trailer can be transported by air and utilizes self-contained power sources. All aircraft within operational radius can query Radfac and check out their own systems, either one at a time or simultaneously. Although developed especially for the F-105, the new system needs only minor modifications to adapt it to other types of electronic equipment and aircraft.

Happy with Your Job? Many Engineers Aren't

Opinion Research Corp. Survey Lists Engineers' Complaints

WASHINGTON—Interviews with 622 scientists and engineers and 105 managers in six major companies engaged in research disclosed a fundamental conflict between scientific and management minds.

Management's need to make and sell products at a profit conflicts with the technical man's quest for knowledge, according to the survey. Sales and profits were recognized as primary company goals by 74 per cent of the technical people interviewed, but fewer than half said they shared these goals.

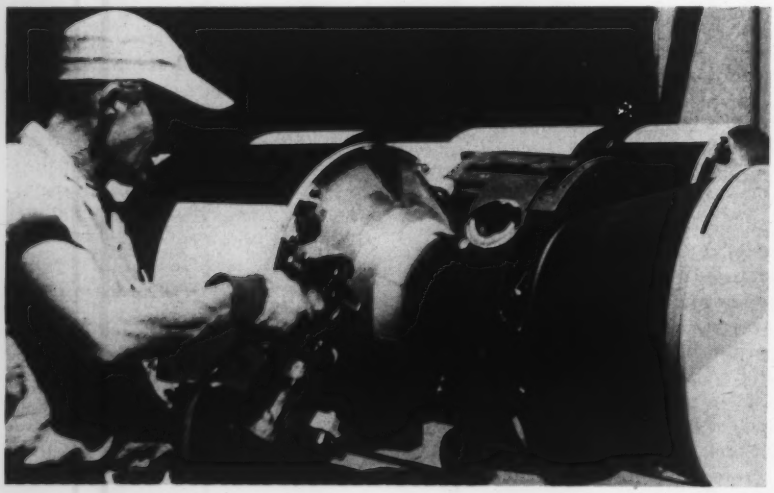
Popular specific complaints were:

- Underpayment, compared with others having similar training and responsibilities (80 per cent)
- Management misuses talents (72 per cent)
- Companies force overspecialization (71 per cent)
- Getting ahead in management requires playing politics (67 per cent)

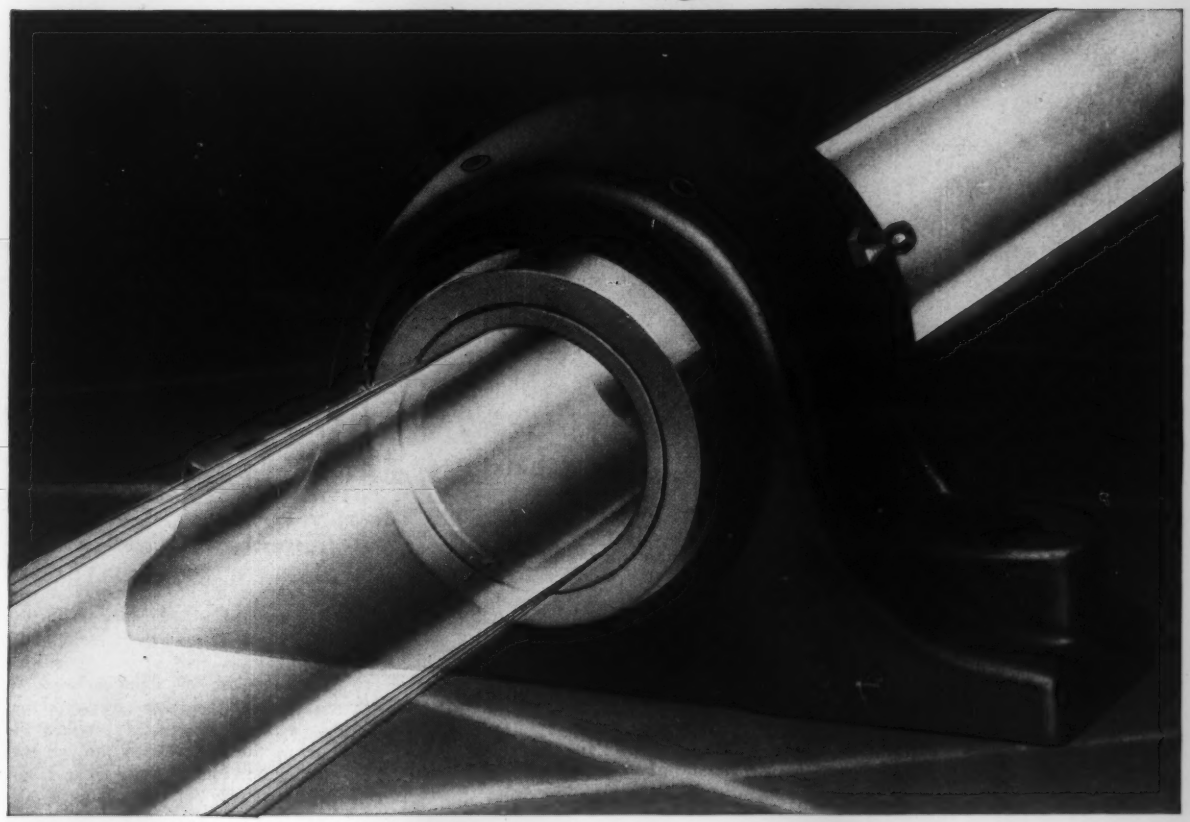
Another complaint was that demand for immediate results, schedules, budgets, and established methods of problem-solving prevent engineers from working in their own way. A member of management said that the place for such freedom is in academic institutions, not competitive industry.

Disappearing Coating Dissipates Heat

Sprayed on like paint, a new family of compounds controls and reduces the temperature of materials subjected to intense heat. Heat is dissipated by sublimation of the "paint." Called Thermo-lag by the developer, Emerson Electric Mfg. Co., St. Louis, the compounds are presently under test for missile use. They require no adhesive or bonding material and can be sprayed or brushed on to any shape structure without molds or forms. Precise temperature control over a wide range of temperatures is obtained by varying the composition of the material so as to sublime at a predetermined point. Once sublimation temperature is reached, all the heat transferred goes into the coating and temperature does not increase until all the coating is "boiled off."



Free rolling . . . long lasting because it's *Self-Aligning*



Link-Belt roller bearings compensate for misalignment of shafts and supports

Link-Belt Series 400 roller bearings have won a reputation as "the designer's choice." These self-aligning, double-row roller bearings compensate for inaccuracies in machining and assembly of equipment while maintaining full load capacity throughout their long life. Their compactness promotes simplicity of machinery design—their easy mounting reduces installation costs.

For complete information on the Series 400 —and Link-Belt's complete line of ball and roller bearings—send for our Book 2550. It's available at any one of the 40 Link-Belt offices.

Look under BEARINGS in the yellow pages of your phone book.

Also available in these mountings:

LINK-BELT

SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,113-A

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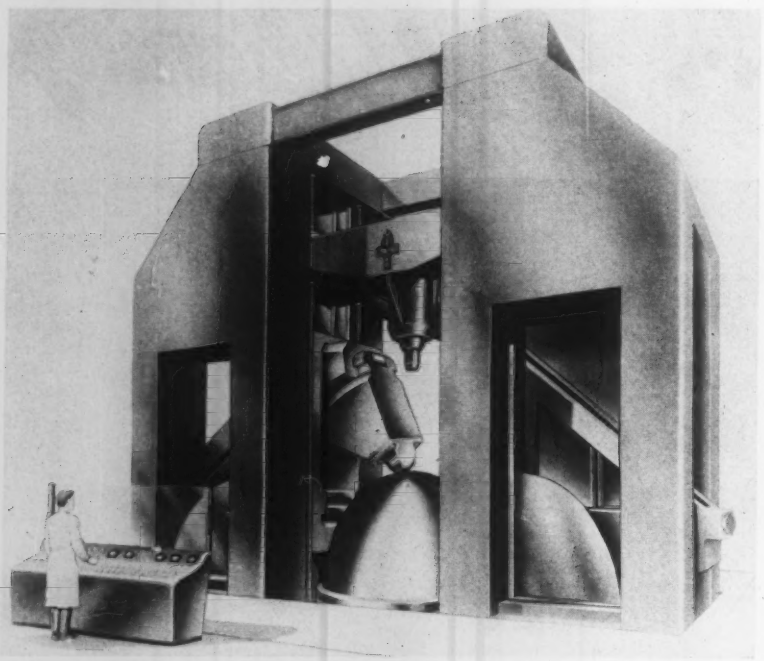
Spin Forges Get Bigger



Missile parts up to 120-in. diameter and 24-ft long will be formed on a new spin forge being built by Hufford Div., Siegler Corp.,, El Segundo, Calif. The immense new tool will measure 22 by 37 by 38 ft and will weigh almost 600,000 lb. According to Hufford spokesmen, a spin forge is the most practical and, in some cases, the only tool for forming missile parts. It produces conical, tubular, and parabolic configurations with varying wall thicknesses to extremely accurate tolerances and finishes. The machine is scheduled for completion by July.

UL Approves Professionalism With Register-Or-Else Edict

Bureau of Public Roads Also Encourages Licensing

WASHINGTON—Engineering professionalism is receiving "vigorous support" from Underwriters' Laboratories, according to the National Society of Professional Engineers. A recent memo to staff engineers from UL's president urged registration and affiliation with professional societies and indicated that promotion to supervisory positions is unlikely for an engineer who is not registered.

About a third of the staff is now registered, and a "substantial number" are preparing for the examinations.

The UL statement read, in part:

"Inasmuch as our organization is primarily an engineering organization, it is incumbent on our engineering staff to advance both their professional knowledge and their professional status in every proper manner, and one of the most important steps in this direction is qualifying under existing laws as a Professional Engineer.

"We also have an obligation to affiliate with one of the professional societies, both for the support we can give their objectives and for the education which such affiliation provides.

"In operations it will be essential in the future to consider professional status in connection with any supervisory engineering job, and that is one reason this situation is called to your attention."

Another memo, issued by the Bureau of Public Roads, encouraged engineers to become registered and to display their licenses. "In this way," says BPR, "visitors to our offices can be made aware of the professional nature of the staff."

Metals Matters

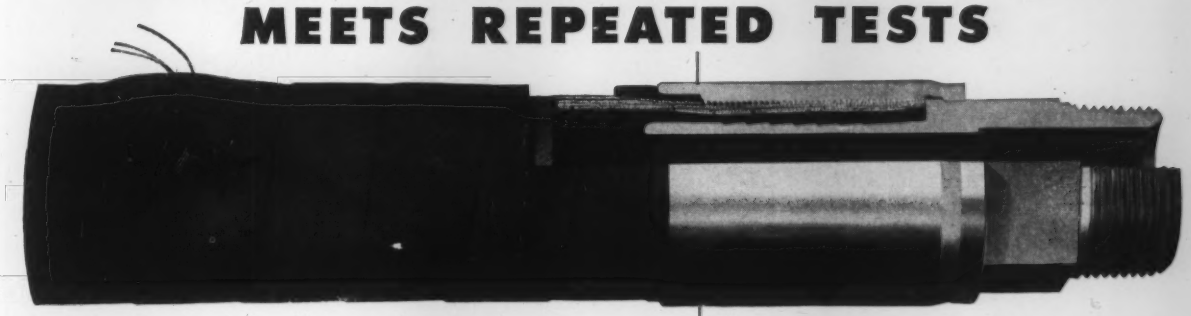
200-lb tungsten ingots . . .
can be formed from powder metal in a new process developed by Schwarzkopf Development Corp., New York. Large blocks of the metal, about 8 in. in diameter and 8 in. high, are formed in large-capacity presses, sintered in high-temperature furnaces, then forged at high temperatures. Until recent years, tungsten had to be processed by direct sintering (consolidating the powders at a temperature below the metal's melting point), swaging, and heat treating. This method limited size of tungsten bars to about 20 lb.

Self-removing coating . . .
prevents scale formation on metal during heat treatment and, in many cases, eliminates the need for further processing. Skalix, developed by North American Aviation Inc., is applied by spraying or dipping. As the heat-treated metal cools, the coating pops off. A gallon of Skalix covers about 1500 sq ft; it can be used on stainless steel, nickel-chrome alloys, cobalt alloys, copper alloys, and exotic alloys. The coating will be marketed by Navan Products Inc., NAA subsidiary.

Free-machining stainless . . .
replacing a chrome-moly alloy steel in fabrication of a critical missile part, resulted in increased production and virtually no rejects. Formerly, about 25 per cent of the parts were rejected. Use of stainless steel, in eliminating the need for cadmium plating, also eliminated problems of holding thread tolerances through machining and plating operations. Higher initial cost of the stainless was offset by savings on plating and finishing operations. Perfection Service Co., Charlotte, N. C., working on a subcontract for Douglas Aircraft Co., made this successful substitution, using AISI Type 416 stainless supplied by Carpenter Steel Co.

Seamless vanadium tubing . . .
has been produced experimentally by Wolverine Tube Div. of Calumet & Hecla Inc. at the Allen Park, Mich., research center. Success of this project was made possible by a new ductile form of commercially pure vanadium and a new extrusion process developed by Wolverine Tube engineers in cooperation with Oregon Metallurgical Corp., Albany, Ore. Vanadium's light weight, high-temperature strength, and corrosion resistance are expected to put the seamless tubing to work in a sodium-cooled nuclear reactor, where it might permit raising the operating temperature by almost 600 degrees.

Eastman APPLICATION MEETS REPEATED TESTS



Tests prove that Eastman couplings applied to super high pressure 4-ply spiral wire hose assure successful assemblies. Couplings hold well above minimum burst pressure.

PERMANENTLY ATTACHED COUPLINGS PROVIDE BOND STRONGER THAN HOSE ITSELF!

Increasing demand for greater power brought about the use of higher pressures in hydraulic systems. This not only calls for greater hose strength, but far more critical engineering in coupling design and application.

EASTMAN is contributing toward the development of the trend toward higher pressures—not only in the design and application of coupling to hose—but in the more exhaustive tests required to assure adequate safety under high pressure operations.

The actual photo above is typical of many tests in Eastman laboratories proving that the hose did not fail at the coupling—demonstrating that the coupling was designed and applied to form *a bond which was stronger than the hose itself.*

If you have an application requiring higher pressures, let our engineering department demonstrate the superiority and economy of Eastman applications, and quote on complete Hydraulic Hose Assemblies.

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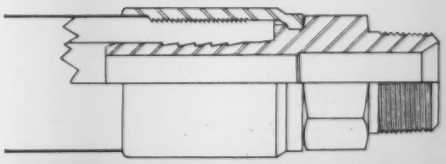
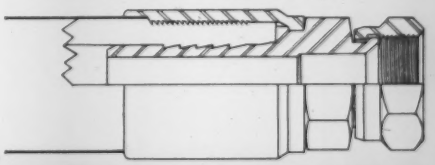
WRITE today for your copies—
Technical Bulletin 100—Medium Pressure Hose and Tube Assemblies, Couplings and Fittings for One Wire Braid Hose.
Technical Bulletin 200—High Pressure Hose and Tube Assemblies, Couplings and Fittings for Multiple Wire Braid Hose.

MALE NPTF



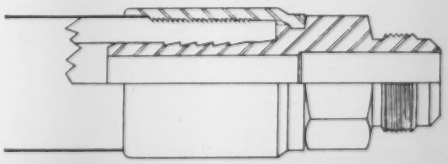
Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12M	¾	1 7/16	19/32	20,000	5,000
8416-16M	1	1 ¾	25/32	16,000	4,000
8420-20M	1 ¼	2	1 5/64	12,000	3,000
8424-24M	1 ½	2 ¼	1 21/64	10,000	2,500

SWIVEL FEMALE JIC-37°



Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12FH	¾	1 7/16	19/32	20,000	5,000
8416-16FH	1	1 ¾	25/32	16,000	4,000
8420-20FH	1 ¼	2	1 5/64	12,000	3,000
8424-24FH	1 ½	2 ¼	1 21/64	10,000	2,500

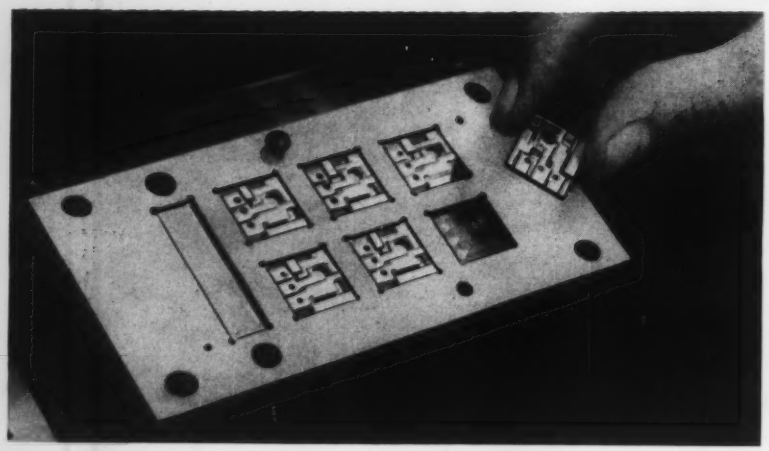
MALE JIC-37°



Catalog No.	Hose I.D.	Hose O.D.	Coupling I.D.	Min. Burst Pressure (P.S.I.)	Max. Wkg. Pressure (P.S.I.)
	(inches)				
8412-12MH	¾	1 7/16	19/32	20,000	5,000
8416-16MH	1	1 ¾	25/32	16,000	4,000
8420-20MH	1 ¼	2	1 5/64	12,000	3,000
8424-24MH	1 ½	2 ¼	1 21/64	10,000	2,500

One More Step Toward Zero-Size Electronics

Evaporated onto postage stamp-size plates, new Micro-circuits are formed from almost weightless components. Developed by International Resistance Co., Philadelphia, circuits are made up of thin films on a tiny substrate of glass. Resistors, capacitors, and inductors are deposited on the glass substrate in thin film form with a value tolerance of five per cent or (if needed) better. Developed especially for missileborne computer applications, the circuits should also find many other jobs, company spokesmen predict.



Defense Digest

World altitude record . . .
for conventional aircraft, now held by the Soviet Union (94,657 ft), will soon be challenged by U. S. Navy. Modified version of McDonnell Aircraft Corp.'s F4H twin-jet fighter will attempt the mission. Equipped with advanced General Electric J79 engines, the F4H will have an altitude capability of more than 100,000 ft.

Dyna-Soar . . .
the manned boost-glide vehicle conceived as a global-range weapon system, will be built by both Boeing Airplane Co. and Martin Co., according to a long-awaited Air Force decision. Boeing will develop the glider and Martin, the rocket booster. Since the vehicle will be the first to fly in near space and return by means of an aerodynamic vehicle, all of the latest knowledge in space, missile, and aeronautical technologies will be wrapped up in the design. Biggest current problem centers around cooling, and the full spectrum of "exotic" materials is being culled for hypersonic leading-edge material (3000 F) and hot structural material. No flights are expected for at least three years, but Dyna-Soar astronauts have already been chosen.

Transport versions of B-70 . . .
have been proposed to the Air Force by North American Aviation. The Mach-3 bomber would seat 80 passengers without any external change in configuration. Use of a larger fuselage would permit the craft to carry 180 people. B-70 has also been seriously proposed as a recoverable launcher for satellites and as first stage for the Dyna-Soar vehicle.

Biggest missile decision . . .
since the go-ahead on Atlas is expected late this year—it concerns the fate of Nike-Zeus. Final word on the missile-killer will probably come from the President, since Zeus would require a tremendous slice of the defense budget (up to $13 billion for a "complete" system). First-stage booster for Zeus is the largest solid-fuel rocket motor ever fired: 400,000-lb thrust versus 360,000 lb for the liquid-fuel Atlas booster. The missile has performed once—after a successful launching, the flight terminated when Zeus broke up.

Last non-nuclear submarine . . .
has joined the U. S. fleet. Recent commissioning ceremonies for Blueback marked an end of diesel-electric sub construction, although Navy brass described Blueback as having an "awesome potential." The teardrop-shaped vessel is designed for submarine killer service; its outstanding design quality, quietness.

Operational B-58s . . .
will soon be added to SAC weapons inventory. Conversion of 13 Hustlers from flight-test to operational status is now underway. B-58 grew from an Air Force design study competition won by Convair in 1949. Design was frozen in 1952 when go-ahead was signaled to produce the craft as a flyable bomber. First flight was made in November, 1956. Air Force now has firm orders placed for 66 Hustlers, with long-lead-time items on order for 40 more. Although the plane is normally considered to be a high-altitude weapons-delivery system, it recently displayed versatility by flying 1500 miles nonstop at maximum altitude of 500 ft.

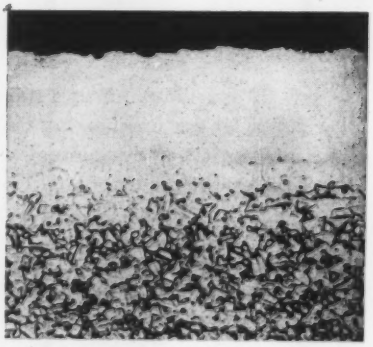
New Platinum-Clad Steel Resists Attack by Hot Acids

ATTLEBORO, MASS.—Platinum alloy (5 per cent rhodium) can now be clad to stainless steel (Carpenter 20). The composite material, developed by Metals & Controls Div., Texas Instruments Inc., is being fabricated in sheet, wire, and tubing.

Stronger and as corrosion resistant as pure platinum, the new composite costs only 1/6 as much. Because ability to stop acid attack at high temperatures (1000 F and above) depends on platinum thickness, the clad is available in thicknesses ranging from 0.0001 to 0.005 in.

The platinum is inseparably clad to the stainless by a solid-phase bonding process without use of brazing alloy or other intermediate material.

Several applications are currently

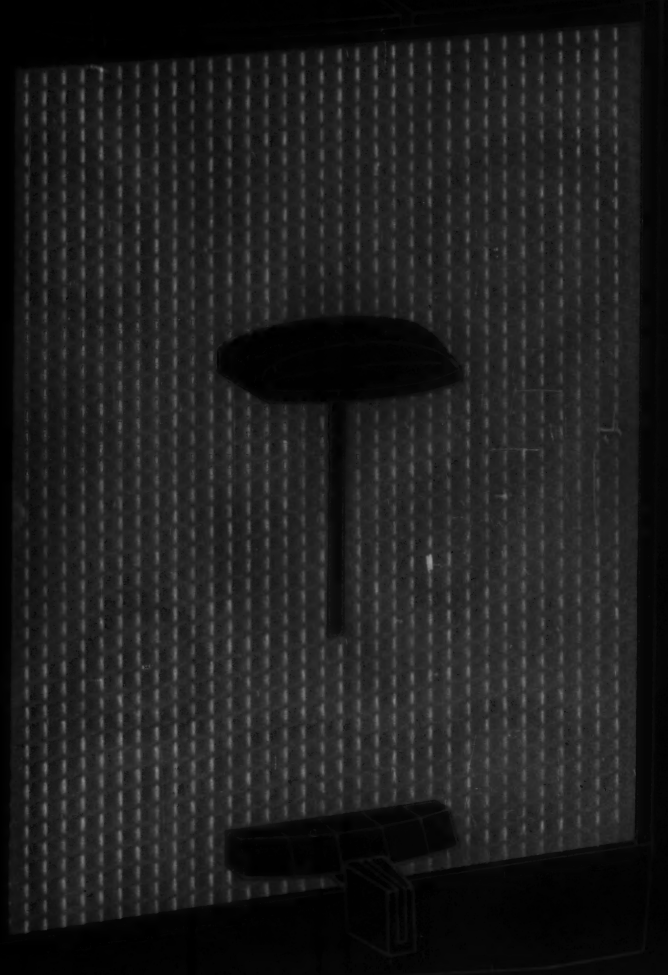


Photomicrograph at 500X magnification shows about 15 per cent of the platinum has alloyed with the stainless steel. Sample was exposed to 1500 F for one month. This amount of diffusion is allowable and will not affect acid resistance.

Circle 418 on Page 19→

Gold-finished panels of USS American Embossed Amerstrip add richness, smart modernity to classic toaster lines

New Proctor Electric Company toaster styled by Raymond Loewy Associates has special design USS Embossed Amerstrip



This Mary Proctor toaster is beautiful—and different. On the sales counter it stands out from its competitors. Much of this sales-pulling distinction lies in the end panels formed from gold-finished, geometric-patterned Embossed Amerstrip. This effective pattern was created by famous industrial designers, Raymond Loewy Associates, and was rolled by American Steel & Wire.

The USS Embossed Amerstrip was given a No. 4 temper which is especially suitable for formulation work. It was rolled to .0239-inch thickness and trimmed to 5⅞-inch width with a No. 3 slit edge. So that the strip would make a good bond with the gold plate it was supplied with a No. 3 finish—the best finish available on strip. It is guaranteed against surface defects and has a sufficiently high lustre to make buffing or polishing before plating unnecessary. To protect the finish and the embossed design, the coils were interleaved with rolls of paper before shipping.

American Steel & Wire specializes in the rolling of special embossed designs for specific applications. If you have a product which could be made more beautiful or more sales-appealing with Embossed Amerstrip, get in touch with American Steel & Wire. Write to 614 Superior Avenue, N.W., Cleveland 13, Ohio. *USS and Amerstrip are registered trademarks*

American Steel & Wire Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal and Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, Distributors Abroad

in the development stage, and at least one application is now in use (in the processing of a new plastic material), Texas Instruments reports.

Meetings and Shows

Jan. 11-13—

Sixth National Symposium on Reliability and Quality Control in Electronics to be held at the Statler Hilton Hotel, Washington, D. C. Sponsors are Institute of Radio Engineers, American Society for Quality Control, Electronic Industries Association, and American Institute of Electrical Engineers. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Jan. 11-15—

Society of Automotive Engineers Inc. Annual Meeting and Engineering Display to be held at the Sheraton-Cadillac and Statler Hotels, Detroit. Further information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Jan. 12-15—

Society of Plastics Engineers. Annual Technical Conference to be held at the Conrad Hilton Hotel, Chicago. Further information can be obtained from Mr. T. A. Bissell, Executive Secretary, SPE, 65 Prospect St., Stamford, Conn.

Jan. 15—

Malleable Founders Society. Semiannual Meeting to be held at the Hotel Sheraton - Cleveland, Cleveland. Further information is available from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

Jan. 20-22—

American Management Association. Conference on Utilizing Technology to be held at the Hotel Roosevelt, New York. Additional information can be obtained from AMA headquarters, 1515 Broadway, New York 36, N. Y.

Jan. 25-28—

Institute of the Aeronautical Sciences. Annual Meeting to be held at Hotel Astor, New York. Further information is available from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

Jan. 25-28—

Plant Maintenance and Engineering Conference to be held at Convention Hall, Philadelphia. (Conference dates are Jan. 25-27.) Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Jan. 26-27—

Society of Vacuum Coaters. Third Annual Meeting to be held at the Hotel Biltmore, New York. Technical sessions will be on Wednesday. Further information is available from John H. Smith, Application Engineer, Technical Services Dept., Consolidated Electrodynamics Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.

Jan. 31-Feb. 5—

American Institute of Electrical Engineers. Winter General Meeting to be held in New York. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Feb. 1-4—

American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. Semiannual Meeting to be held concurrent with the Second Southwest Heating and Air-

"We employ only one designer —right now he's having his annual office party."

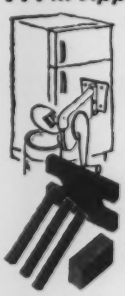
←Circle 418 on Page 19

HOW CERAMIC MAGNETS ENERGIZE NEW IDEAS

. . . In Liquid Flow Registers

Water and liquid meters can be read at a distance with the remote-indicating "Read-O-Matic" Register of the Badger Meter Mfg. Co., of Milwaukee. Heart of this self-contained generator is an inexpensive 6-pole ring magnet of Stackpole Ceramagnet. The quick release of the magnet under spring tension induces a 3-volt pulse in 6 coils. This is transmitted to a remote totalizer.

. . . In Appliances • Powerful, low cost Ceramagnet ceramic permanent magnets open, close and hold doors; put *snap* into snap-action switches and thermostats; catch lids from can openers . . . make other magnet uses practical for the first time. Ceramagnet requires no keepers; retains magnetism indefinitely, can be molded in practically any shape.



. . . In Automotive Equipment

High coercive force and high electrical resistivity make Ceramagnet ideal as field magnets in small dc motors. They are likewise being investigated for fuel-pump drives, speedometers, ammeters, carburetors, and many other new devices.

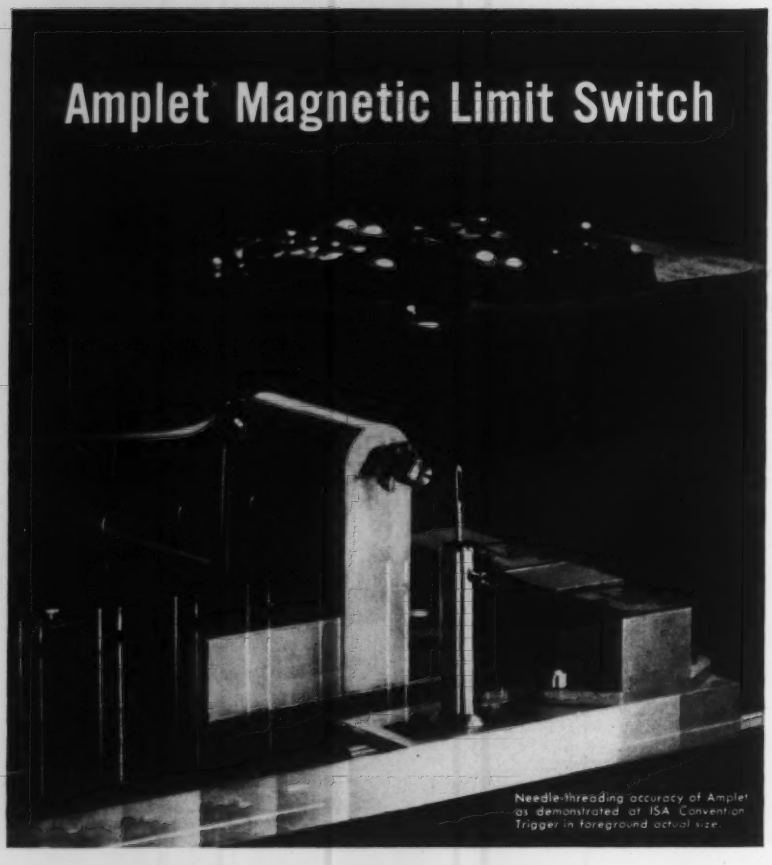
Where can YOU use Ceramagnet? For practical suggestions, and engineering details, write for Stackpole Bulletin, RC-12A. STACKPOLE CARBON COMPANY, St. Marys, Pa.

STACKPOLE Ceramagnet

FERRITE PERMANENT MAGNETS

Circle 419 on Page 19

Amplet Magnetic Limit Switch



Needle-threading accuracy of Amplet as demonstrated at ISA Convention. Trigger in foreground actual size.

9 times more accurate than conventional proximity systems

This new Amplet® Magnetic Limit Switch operates with uncanny accuracy . . . 9 times more accurate than conventional proximity systems. It acts on the proximity of two miniature sensing elements . . . and provides a new standard for precision control of all types of machine motion.

Amplet meets the most rigid specifications for long life, environmental conditions and continuous accuracy. Check these important features . . . • High repeat accuracy, to ±.001″ on successive approaches • Adjustable differential as low as .002″ • Differential accuracy is maintained within ±.001″ • True snap action . . . 1 millisecond response time • Nothing to wear out, static devices are used throughout • Trigger distance variable from .020 to .200″ for "on" signal, greater distances available on special order.

Amplet has only three basic parts. A probe mounts on a stationary part of the machine, a magnetic trigger mounts on the moving part and becomes the actuating element, and the amplifier boosts the probe signal to useful levels. Probe and trigger are completely free from environmental and shock conditions.

APPLICATIONS

The Amplet Magnetic Limit Switch can handle a wide variety of motion control:

- Machine Tools — Limiting cuts or traverse on shaper, planer, automatic drill press.
- Transfer Machines — Position stop on multi-station transfer conveyor.
- Automated Production — Continuous sequencing and counting.
- Measurements — Automatic weighing and filling.

FIND OUT ALL ABOUT THE NEW AMPLET . . . . *Complete specifications, application information and sensitivity characteristics are available for you now. Call or write, today.*

CONSOLIDATED CONTROLS CORPORATION / A SUBSIDIARY OF CONSOLIDATED DIESEL ELECTRIC CORPORATION

BETHEL, CONNECTICUT

CCD-5

Conditioning Exposition, which is under the auspices of ASHRAE, in Dallas. Headquarters for the society meeting will be the Baker Hotel; the exposition will be in Memorial Auditorium. Further information is available from ASHRAE, 234 Fifth Ave., New York 1, N. Y.

Feb. 1-4—

Instrument Society of America. Instrument-Automation Conference and Exhibit to be held at the Rice Hotel and Sam Houston Coliseum, Houston. Additional information is available from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Feb. 2-4—

Society of the Plastics Industry Inc. Fifteenth Reinforced Plastics Div. Conference to be held at the Edgewater Beach Hotel, Chicago. Further information is available from SPI headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 3-4—

Midwest Welding Conference to be held at Illinois Institute of Technology, Chicago. Sponsors are Armour Research Foundation and the Chicago section of the American Welding Society. Additional information can be obtained from Harry Schwartzbart, Supervisor of Welding Research, Armour Research Foundation, 10 W. 35th St., Chicago 16, Ill.

Feb. 3-5—

Institute of Radio Engineers. Winter Convention on Military Electronics to be held at the Biltmore Hotel, Los Angeles. Additional information can be obtained from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

Feb. 14-18—

American Institute of Mining, Metallurgical, and Petroleum Engineers. Annual Meeting to be held at the Statler-McAlpin Hotel, New York. Further information is available from AIME headquarters, 29 W. 30th St., New York 18, N. Y.

Feb. 17-18—

Malleable Founders Society. Fifth Technical and Operating Conference to be held at the Wade Park Manor, Cleveland. Additional in-

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formation can be obtained from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

Feb. 18-20—

National Society of Professional Engineers. Winter Meeting to be held at the Broadview Hotel, Wichita, Kans. Additional information can be obtained from NSPE headquarters, 2029 K St. N.W., Washington 6, D. C.

March 6-9—

American Society of Mechanical Engineers. Gas Turbine Power and Hydraulic Conference to be held at the Rice Hotel, Houston. Additional information can be obtained from ASME, 29 W. 39th St., New York 18, N. Y.

March 7-8—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Further information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 21-24—

Institute of Radio Engineers. National Convention and Radio Engineering Show to be held at the Waldorf Astoria Hotel and the Coliseum, New York. Further information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

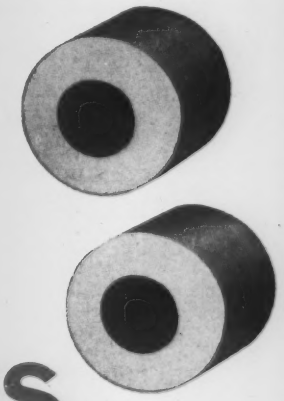
"Another great year — another terrific bonus! How do you want it — nickels or dimes?"

TEFLON,* KEL-F† MOLDED PARTS COME IN 2 PRICE RANGES

One is the cost of a *perfect* piece. The other is the cost of an *acceptable* piece.

Garlock's Plastics Division, The United States Gasket Company, will quote both ways. If you require perfection in every sense, then U.S.G. will furnish it. If "leeways" in tolerance or mold finish, for instance, are permissible, then U.S.G. can possibly suggest ways to save 20-25% of the total cost of a molded piece.

Guarantee yourself the right price and right quality every time. No matter how intricate the shape, how thin the wall sections, or how close the tolerances, ask your local Garlock representative to quote on your molded Teflon or Kel-F parts. Call him, or write.



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For Prompt Service, contact one of our 26 sales offices and warehouses throughout the U.S. and Canada.

*DuPont Trademark for TFE Fluorocarbon Resin
†M.M. & M. Trademark

United States Gasket Plastics Division of GARLOCK

Circle 421 on Page 19

TESTED SYMBOLS OF DEPENDABILITY...

At Plastic and Rubber Products Company each production process used in the manufacture of exacting rubber products is symbolic of ultimate quality and dependability. Each has been tested and proved for years to attain this symbolic stature. Each contributes a maximum to ultimate customer satisfaction—the final criterion of product quality.

Research is conducted with the customer's needs always in mind. His specialized uses, problem areas, specific requirements, are thoroughly investigated.

Mixing is scientifically performed. All ingredients are laboratory tested and combined according to recipe. Only after each mix is laboratory analyzed is it released for production.

Accurate pre-forming minimizes molding defects. Pre-formed parts are carefully weighed and shaped to provide optimum molding characteristics.

Only Parco can offer Parco-Matic molding which is automatic and electronically controlled to eliminate time and temperature errors. Prolonged scientifically trained operator experience eliminates less tangible errors.

Exacting final inspection provides a comprehensive "double-check" on all previous processes, and assures ultimate product quality.

Send today for your free PARCO Pic-O-Ring desk / wall chart. A must when "O" Rings are concerned.

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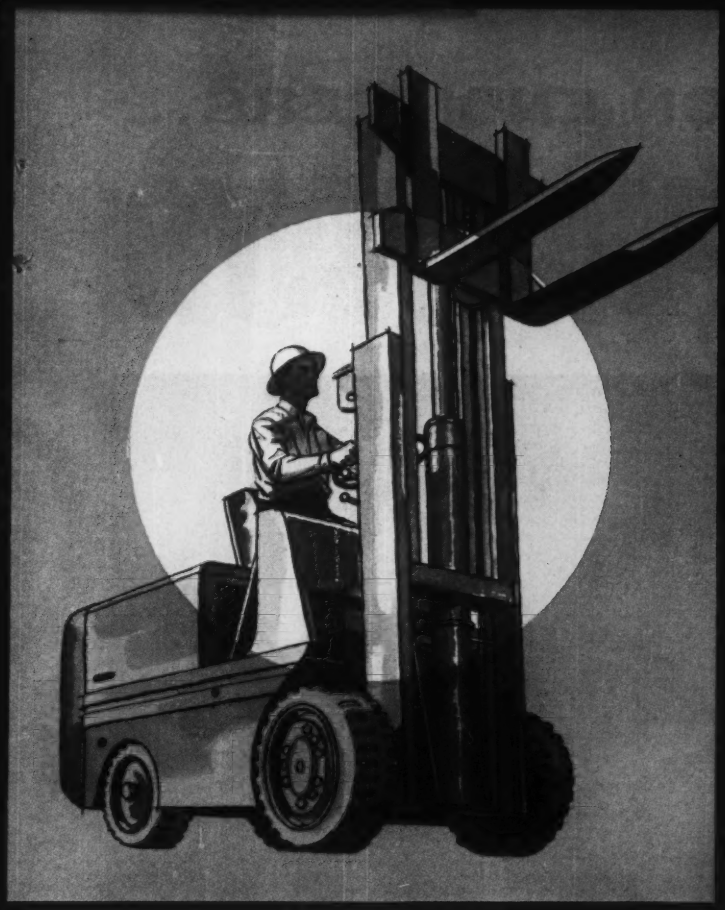

FROM LIFT TRUCKS *TO MISSILE LAUNCHERS*

American Bosch Hydraulic Accumulators do more work at less cost

From lift trucks to missile launchers, American Bosch piston-type hydraulic accumulators—rugged, compact, dependable—are gaining use in a wide number of industrial applications.

As power storage chambers—to provide energy for engine cranking systems, missile launchers, ground handling equipment, and numerous marine and industrial actuating mechanisms.

As system pressure compensators—to automatically maintain system pressure by absorbing or expelling hydraulic fluid caused by changes in temperature, internal leakage or other causes.

As fluid dispensers—to store and dispense a variety of lubricants or liquids under controlled pressure.

As transfer barriers—to serve as pressure transfer agents when a flexible barrier is required between fluids or fluid and gas.

As shock and vibration absorbers—to act as surge chambers for smoothing high-pressure hydraulic pulsations . . . also as shock-cushioners for hydraulically operated mobile equipment.

Built to conform to MIL-A-5498C, ASME, JIC and U. S. Coast Guard specifications, and to operate over a wide range of temperatures, American Bosch piston-type accumulators may be mounted on convenient brackets in any position. They are available in one-pint to 10-gallon capacity and for pressures up to 5000 p.s.i. Or they can be custom-made to your specifications. Write for illustrated brochure AC 110-02-2 or contact your nearest American Bosch accumulator distributor. American Bosch, Springfield, Massachusetts, a division of American Bosch Arma Corporation.

AMERICAN BOSCH ARMA CORPORATION

7408

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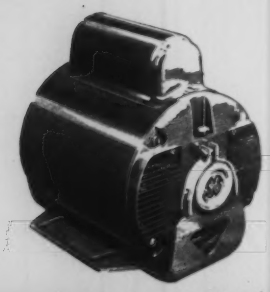
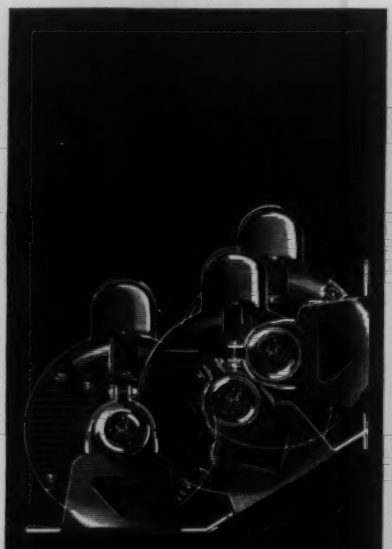


DESIGN ENGINEERS...

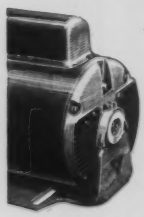
SIX WAYS

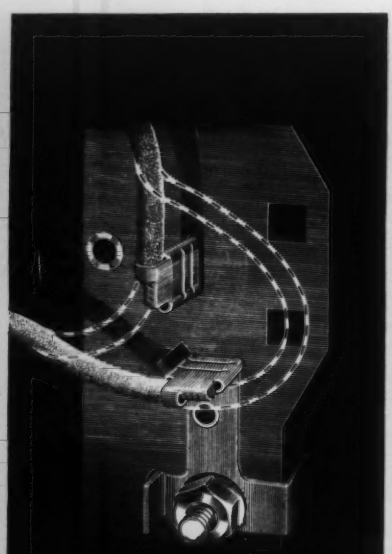


MOUNTING VERSATILITY

Cradle bases, both solid and resilient, allow rotation within base

You can rotate the Form G motor within the cradle base to take advantage of its drip-proof design, or you can position the motor with the capacitor at various angles for tight-squeeze applications. Or, you can remove the cradle base if you don't need it for your application. G-E Form G mounting versatility can mean greater design flexibility for you!

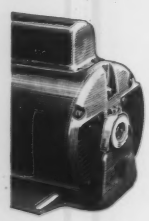


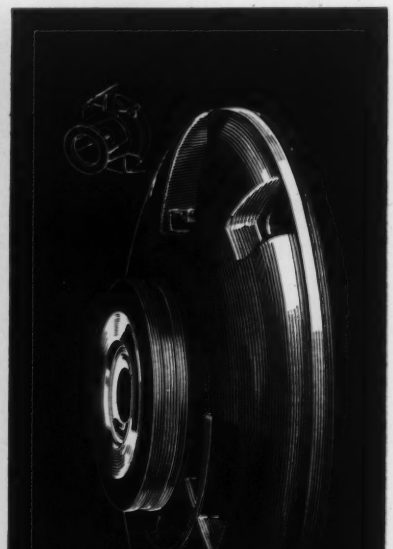


FAST ROTATION CHANGE

Now you can reverse Form G shaft rotation in less than 10 seconds

No need to specially order motors to meet your rotation requirements. G.E.'s Form G motor features a new wiring method that lets you change rotation in seconds. Quick connectors make the change fast and positive. Just interchange the two motor leads on the terminal board. That's all. Require fast, easy rotation change? The Form G is your motor!

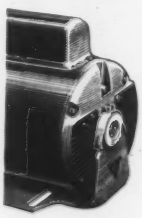




EASY, DIRECT MOUNTING

Close end shield tolerances allow direct mounting without costly machining

General Electric standard Form G's can be mounted directly on your product without expensive machining or costly brackets. Close end shield tolerances, plus inherent shaft-to-end shield concentricity, lets you mount General Electric's Form G's with simple through bolts. This feature could be a real money saver for you. Why not investigate it today?

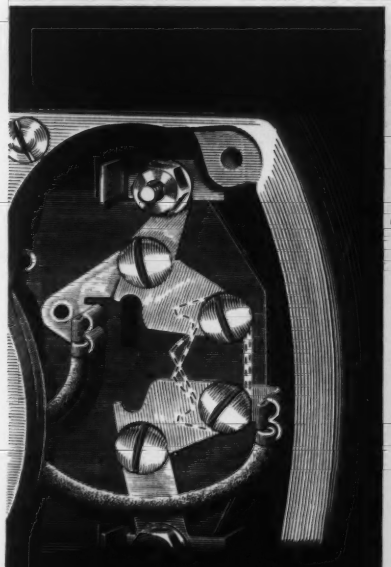


GENERAL ELECTRIC GENERAL ELECTRIC GENERAL ELECTRIC

JUST ASK YOUR GENERAL ELECTRIC SALES ENGINEER

Cut costs with General Electric Form G motors . . .

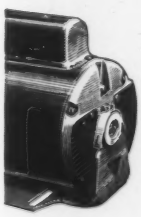
MORE VERSATILE



FAST VOLTAGE CHANGE

Unique sliding plates on terminal boards make voltage change simple

Reduce inventory, simplify ordering! You can change General Electric Form G motors from 115 v to 230 v operation (or vice versa) in 1/5th the time, without confusion and error. No special tools required! A screwdriver is all you need. Just loosen the four screws, pivot the plates to the new position and tighten the screws. That's all there is to it!

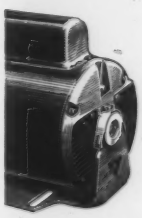


GENERAL ELECTRIC

ALL-ANGLE OPERATION

Special bearing and oil retention system permits mounting in any position

Mount it horizontally, vertically—even upside-down—the new Form G has the versatility to match the design and space requirements of your product. An advanced bearing and full oil retention system allows you to mount the Form G in *any* position and still be sure of getting faithful motor performance. In any position, Form G's do the job!

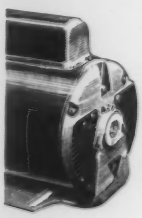


GENERAL ELECTRIC

COMPLETE LINE

Full line of Form G's means the right motor for every application

There's a standard Form G motor to meet your exact product requirements. No need for costly specials. Over 850 basic models—and thousands of variations—are available on a mass-production basis. Let your General Electric Sales Engineer show you the all-around versatility of Form G motors and how they can provide important savings for you!



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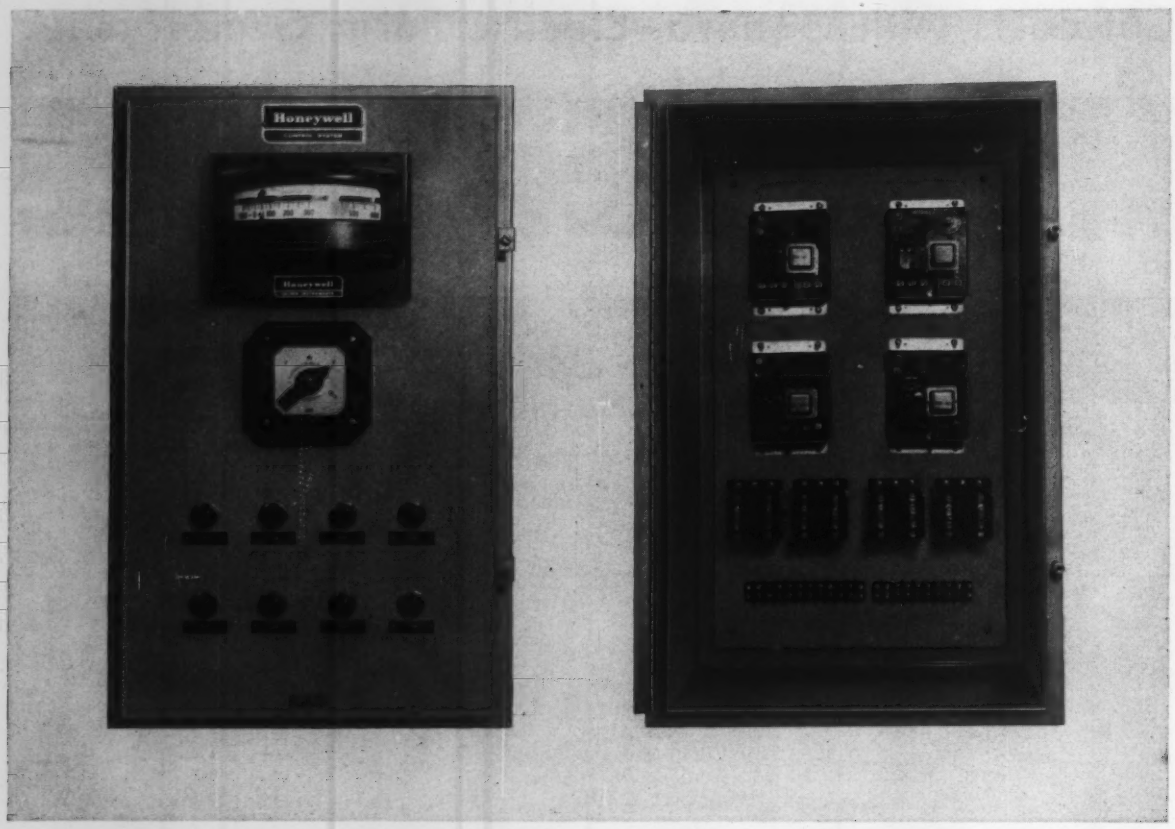
GENERAL ELECTRIC

ABOUT THE NEW FORM G "EXTRA VALUE" FEATURES



NEW VERSA-TRAN* PACKAGE...

FOR PRECISE, LOW-COST CONTROL OF MULTIPLE TEMPERATURES

You get continuous control of several temperatures, with accurate indication of each temperature, in this new packaged *Versa-Tran* system. It offers:

- Close constant control and high sensitivity with individual *Versa-Tran* controllers for each controlled temperature.
- Highly accurate indication with Brown millivoltmeter indicator, selector switch and accurate thermocouples.
- Lower installation costs because complete package is wired ready for mounting.
- Accurate indicator for close setting of individual controlled points.
- Independent settings to permit different settings for each controller if desired.
- Flashing red and green lights to indicate when process temperature is at control setting.
- Any desired number of control points.
- Integral high amperage contactors, if desired.

Versa-Tran controllers are fully transistorized, vibration resistant, and designed for dependable service in even the most demanding applications. They control liquid or air temperatures in a choice of overlapping ranges for all requirements.

Your nearby Honeywell industrial controls engineer can help you profitably apply new *Versa-Tran* transistorized controls singly or in multiple package form. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Minneapolis 8, Minn.

*Minneapolis-Honeywell trademark

75th YEAR PIONEERING THE FUTURE

Honeywell

First in Control

SINCE 1885

Circle 425 on Page 19

LOOK!

LOGAN HAS IT!

RIGHT PRICE
TOP QUALITY
PEAK PERFORMANCE

in hydraulic power devices

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811 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

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COMPANY _____

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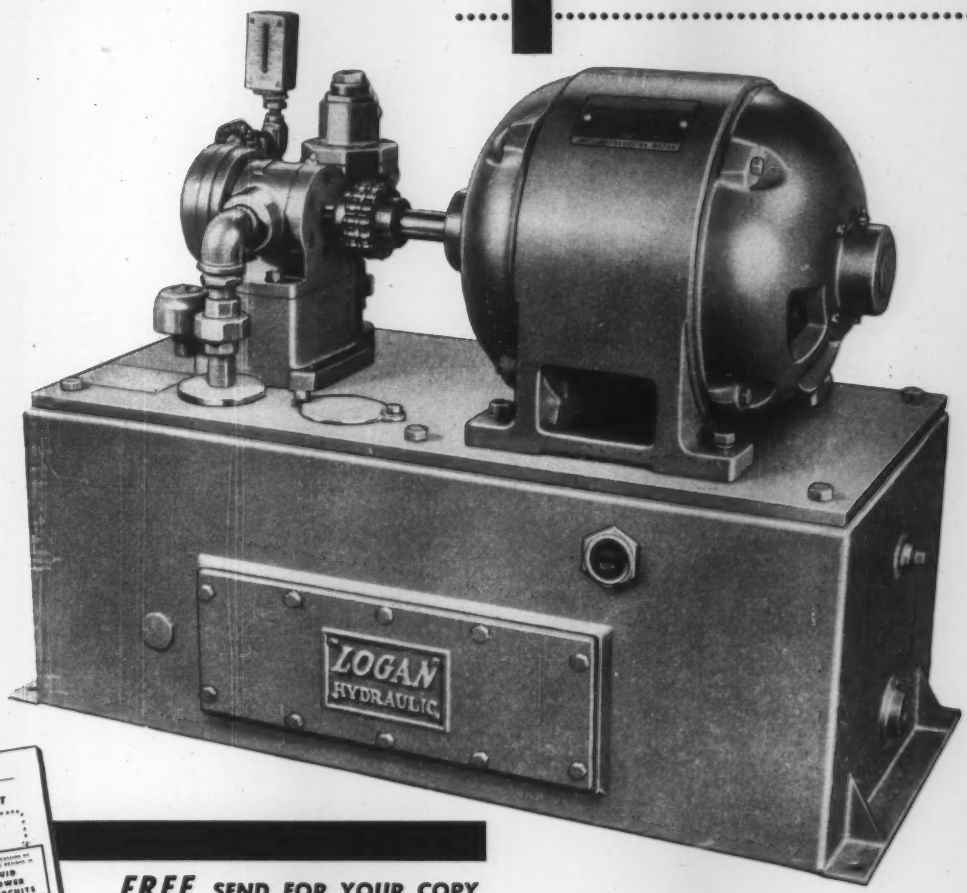


ILLUSTRATED—LOGAN MODEL 6031
HYDRAULIC POWER UNIT

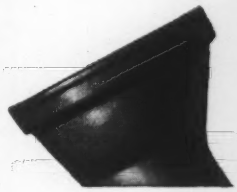
FREE **SEND FOR YOUR COPY OF THE LOGAN "CIRCUIT RIDER"**

A 32-page manual on fluid power circuits (fifth edition) completely revised to present current engineering trends.

MEMBERS: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

FOR THE MACHINERY PART

THAT TAKES THE BEATING



Perfect performance for 100,000 hours at orange heat, in the combustion chambers of diesel engines, is quite an achievement. Yet it's the record of tens of thousands of special combustion cups of HASTELLOY alloy C in a well-known line of diesels.

The alloy was chosen for its unique high-temperature strength and corrosion resistance and its outstanding ability to hold heat.

These and other special properties are built into HAYNES alloys —to fit the particular needs of design and production engineers for machinery parts that must meet the roughest service conditions.

If you are designing such a part, investigate HAYNES alloys. There are more than 15 to choose from. They include HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

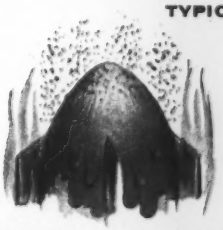
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

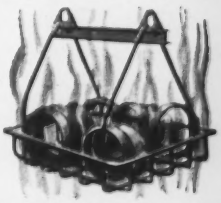
Address inquiries to Haynes Stellite Company, 420 Lexington Avenue, New York 17, N. Y.

The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

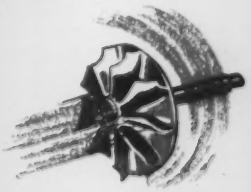
TYPICAL "HAYNES" ALLOY PARTS THAT RESIST...



ABRASION. Ten times the life and still no sign of wear, is the record of this plastics-extrusion torpedo nose made of HAYNES STELLITE alloy No. 3. This is one of many HAYNES wear-resistant alloys.



CORROSION. Baskets made of HASTELLOY alloy C used for holding forgings during acid treatment, are still good after 15 months of service. Materials formerly used were replaced every month.



HIGH TEMPERATURE. Turbine wheels in the "hot" ends of diesel engine turbochargers are investment-cast of HAYNES STELLITE alloy No. 31, for service at speeds up to 50,000 rpm. at 1500 deg. F.

Switch to flash butt-welded compressor ring saves 21.5 lbs. of material—cuts machining time

By selecting a special mill-rolled section close to finished dimensions, only 1/3 as much material was required to produce this ring. (Similar material savings could be realized on extruded sections.)

In addition, 45 minutes of expensive machining time were eliminated.

Flash butt-welded rings like this have been used in critical applications such as jet aircraft engines and present day missiles. They offer cost saving advantages in many fields, particularly where stainless or other heat or corrosion-resistant materials are employed.

Amweld's experience in forming, welding and machining circular parts is available to you. Write or call today. Or send blueprints and specifications—we will be glad to study your problem.

LEARN HOW FLASH BUTT-WELDED RINGS CAN REDUCE PRODUCTION COSTS.

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

AMERICAN WELDING

now the Bruning Man brings you the hardest-working, lowest-cost whiteprinter for its size anywhere!

Designed by Palma-Knapp Associates

A medium-volume machine with big-volume features at a low-volume machine price! That's Bruning's new Copyflex Model 430 diazo-printer. It gives you such important features as big 42-inch printing width, 30 f.p.m. mechanical speed, simple *one*-knob control, automatically synchronized exposure and development, positive pressure-roller development of all types of materials at any speed at a *single* pass, and a split-print stacking tray. Add the famous Copyflex years-ahead construction, odor-free, vent-free operation, and you have the greatest whiteprinter value today. The coupon brings you proof.

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1800 Central Road, Mt. Prospect, Illinois
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Please send me information on your new low-cost Model 430.

Name_____ Title_____

Company_____

Address_____

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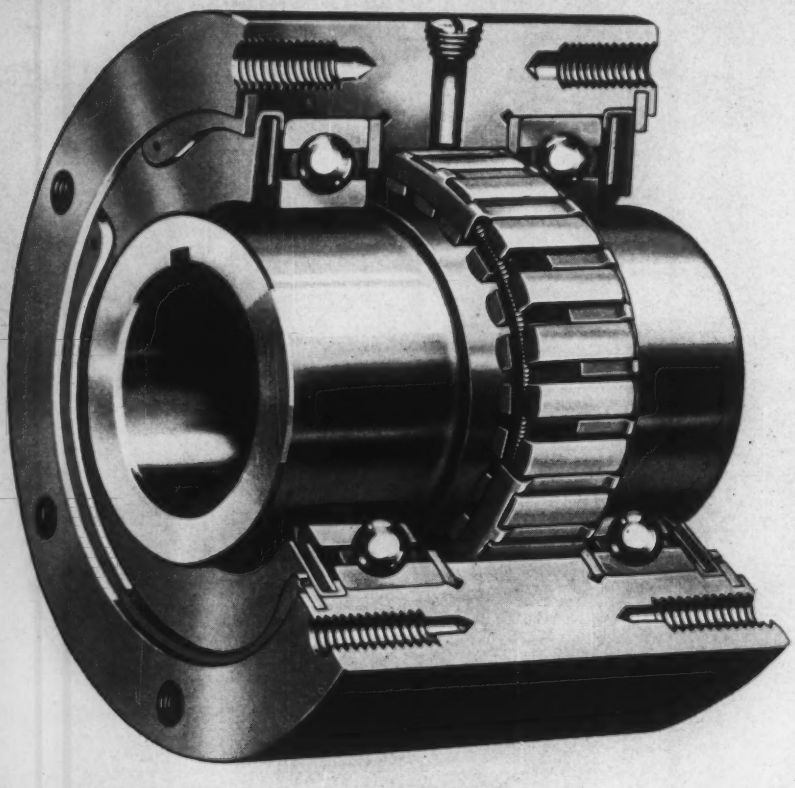
The Bruning Man is your expert on diazo reproduction. He's backed by a company with over sixty years' experience.

Circle 429 on Page 19

NEW! HIGH-PERFORMANCE

This is a high-performance Formsprag clutch having a torque capacity of 475 lbs. ft. and a 1.25" bore diameter. Note sprag and retainer design that assures coordinated yet free-action movement of sprags. Positive sprag engagement, greater torque capacity, higher speed applications and longer clutch life result from this new design.



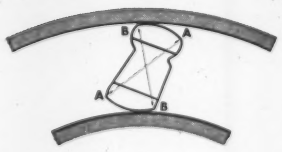
OVER-RUNNING · INDEXING BACKSTOPPING

COMPARATIVE PERFORMANCE CHARACTERISTICS

1. *Longer Life*—Running at identical speeds, an HPO clutch with Formchrome sprags will give you up to 70% longer life than a comparable standard Formsprag over-running clutch.
2. *Increased Speed*—HPO clutches using Formchrome sprags can be operated at up to 30% higher R.P.M. with same life span as a comparable standard Formsprag over-running clutch. Also, the HPO clutch design can be modified for special applications requiring high over-running speeds up to 20,000 R.P.M.
3. *High-Performance Indexing*—Here's a typical example that is characteristic of the entire HPI line. On 15° indexing, a Formsprag HPI clutch with a torque capacity of 475 lbs. ft. can be operated at 1,200 indexes per minute without slip or backlash.

For further information on these High-Performance Over-running and Indexing clutches, send for descriptive brochure.

HERE'S



The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension AA is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.

FORMSPRAG CLUTCHES

FOR OVER-RUNNING · INDEXING

Formsprag clutches have always provided greatest torque for size and weight, higher precision, no measurable backlash and long, trouble-free life. However, designers and users often have applications for over-running and indexing clutches where even higher performance characteristics are required.

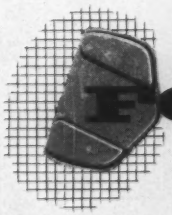
To meet this need for super-performance, Formsprag has perfected a new line of High-Performance Over-running (HPO) clutches and a new line of High-Performance Indexing (HPI) clutches.

The HPO and HPI clutches have an improved sprag design and retainers that assure a coordinated movement of all sprags but each sprag also has a free-action feature. The design assures: positive engagement of every sprag—uniform distribution of driving load over all sprags—greater torque capacity for clutch size. This same "Free-Action" operation of sprags also assures there will be a minimum of drag on all sprags during over-running. Result, clutch can operate at higher speeds, there is less wear on all clutch components and longer clutch life is obtained.

There is a Formsprag clutch size and model for every application—from business machines to aircraft. HPO, HPI and standard FS clutches are completely described in a new brochure, write for your copy.

FORMSPRAG COMPANY
23603 Hoover Road, Dept. 103
Warren (Detroit), Michigan

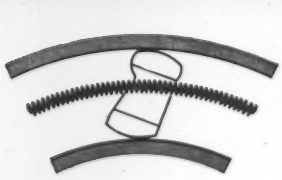
In Canada: Renold Chains Canada, Ltd.
In United Kingdom: Renold Chains Limited
Distributors in Principal Cities.

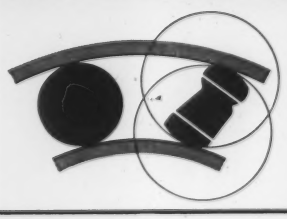


FORMSPRAG CLUTCHES

World's Largest Exclusive Manufacturer of Over-running Clutches

HOW IT WORKS

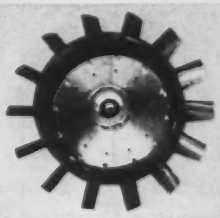




An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.

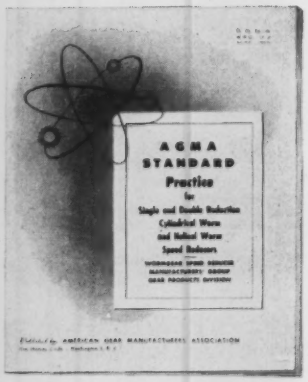
RAWSON FOR NO-LOAD STARTS



The compactness, reliability and maximum capacity of Rawson Clutches have proven especially effective in aircraft applications such as helicopter transmissions. Used in a wide variety of other applications, Rawson Clutches eliminate costly reduced voltage starting equipment, permit use of lower cost smaller motors and provide full overload protection. Write for your copy of Rawson Clutch Catalog.

DE LAVAL offers new A.G.M.A. Gear Standards Booklet for Engineers

You will not want to be without this newly published American Gear Manufacturers Association booklet. It outlines the new standards for single and double reduction cylindrical worm and helical worm speed reducers.



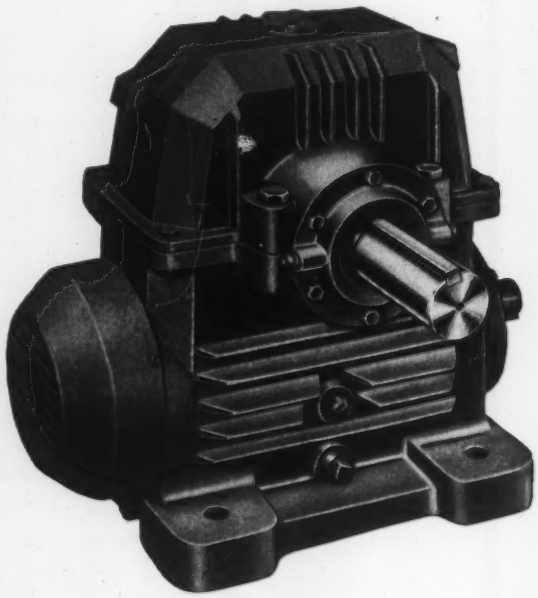
Get this new A.G.M.A. 440.03 booklet free of charge by request on your company letterhead.

This new standards booklet contains important design data including: Power rating of worm gears • Ratio correction factor (Km) • Materials factors (Ks) • Velocity factor (Kv) • Coefficient of friction (μ) • Thermal factor • Service factors • Efficiency • Overhung load capacity • Lubrication.

The materials factor (Ks) and the coefficient of friction (μ) are new, reflecting the latest advances made in worm gearing in the past few years.

We have also recently published our new Delroyd Worm Gear Sets Catalog 3800 and Delroyd Single Reduction Worm Gear Catalog 3805, which contain comprehensive information on the selection of these units.

De Laval furnishes worm gearing under the trade name DELROYD and has a complete line from 1⅛″ to 36″ center distance, in horsepower ranges from .04 to 700 and in ratios from 5: to 4900:.



DE LAVAL *Steam Turbine Company*

858 NOTTINGHAM WAY, TRENTON 2, NEW JERSEY

DL-482

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

Circle 431 on Page 19→

Cleaner, cooler operation . . . less maintenance . . . longer, trouble-free life

HERE'S WHY: Ordinary d-c motor ventilation systems draw air in at the commutator end, contaminate windings by drawing carbon dust from commutator brush wear *into* the machine. In the new Life-Line* "H," this air flow is reversed. Air and carbon dust are expelled at commutator end . . . assuring cleaner, cooler windings . . . longer motor life . . . less maintenance.

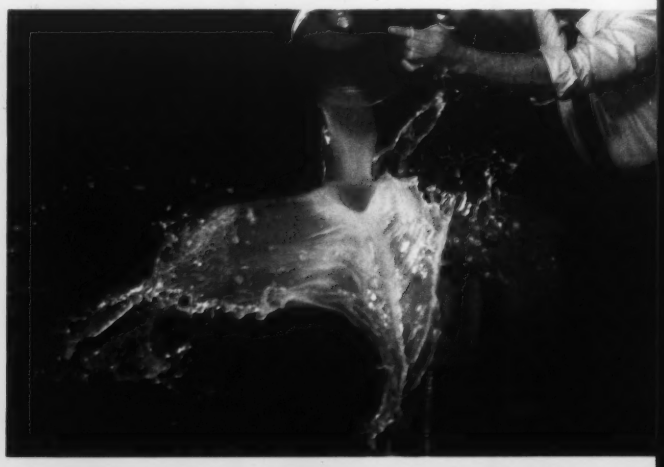
Plus . . . these other important advantages .....

YOU CAN BE SURE...IF IT'S Westinghouse

These exclusive features of the new Westinghouse Life-Line H d-c motor guarantee top performance . . . longer, trouble-free life

TEN TIMES LONGER INSULATION LIFE . . . New silicone insulation in Westinghouse Life-Line* "H" d-c motors and generators stands up under temperatures which turn ordinary insulation to a cinder. High-temperature silicone insulation is used with the full complement of iron and copper required for low Class B temperature. Result: Life-Line "H" shrugs off emergency overloads and abnormal ambients to keep production rolling, maintenance down.

GREATER PROTECTION . . . most complete and advanced protection available in dripproof industrial d-c machines. Elimination of uncovered side openings . . . heavy, cast end brackets . . . effective seals throughout . . . all combine to provide outstanding resistance to liquids, vapors and dirt. This means longer life with greater reliability . . . minimum maintenance under all operating conditions.



FASTEST RESPONSE . . . 35 per cent increase in commutating ability . . . up to 55 per cent lower mechanical inertia . . . and up to 30 per cent reduction in electrical inertia mean that the new Westinghouse Life-Line "H" d-c motor provides the fastest acceleration, quickest reversing and closest speed regulation. This means more production, better product quality, minimum complexity of control.

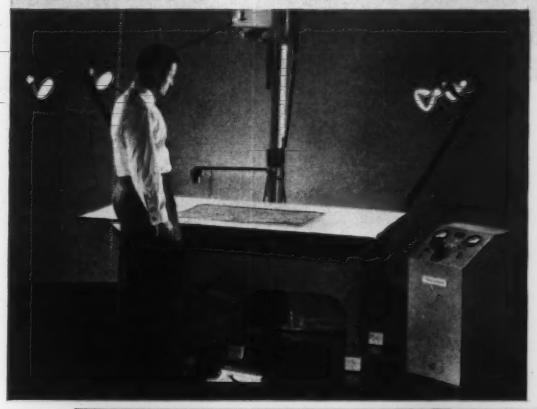
SIMPLIFIED MAINTENANCE . . . With the new Life-Line "H," maintenance is not only substantially reduced but periodic inspections are also greatly simplified. For example: as shown above, Uniforce brushholder fingers lock out . . . brushes can be inspected or changed with one hand. And Uniforce tension remains constant throughout brush life . . . no need to adjust pressure as brushes wear.

For information about the ways you can profitably put the new Life-Line "H" motor to work, contact your nearby Westinghouse representative. Or, write Westinghouse Electric Corporation, P. O. Box 868, 3 Gateway Center, Pittsburgh 30, Pa. J1-22122

YOU CAN BE SURE...IF IT'S Westinghouse

"Any drawing out of thousands found in a minute or less!"

See how Recordak Precision Engineering Drawing System speeds engineering and drafting routines for Cook County, Illinois, Highway Dept., now engaged in a multi-million-dollar highway expansion program.



Mr. F. A. Cerwin, Record Administrator, looks over Recordak Microfilm file, now the *active* drawing file for Cook County Highway Department

FIRST STEP for Cook County was to put its tens of thousands of drawings on 35mm Recordak Microfilm, using techniques and quality-control methods developed by Recordak through years of research. The resulting negatives are needle-sharp images with remarkably uniform backgrounds. Mounting each frame in its own Filmsort aperture card completes job.

RESULTS: New "microfilm" drawing file takes 95% less space. Makes reference in film reader a snap. Ends need for costly reference blueprints that clog up the files! Reduced-size paperprints, when needed, are made by photographic, xerographic or electrostatic methods. Another advantage: a positive film copy of master negatives provides a security copy at negligible cost.

Why not see for yourself? If you're interested in greater drafting room or general office efficiency and want to save valuable time, you should talk to a Recordak Representative soon. Free booklet also available. Mail coupon today.

MAIL COUPON TODAY

RECORDAK CORPORATION DD-12
415 Madison Avenue, New York 17, N. Y.

Gentlemen: Send free booklet describing new Recordak Engineering Drawing System. No obligation whatsoever.

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RECORDAK®

(Subsidiary of Eastman Kodak Company)

originator of modern microfilming
—now in its 32nd year

You're in for a Hot Time

but Fenwal's New Miniature

Hermetically Sealed THERMOSWITCH® Unit will control it—precisely!

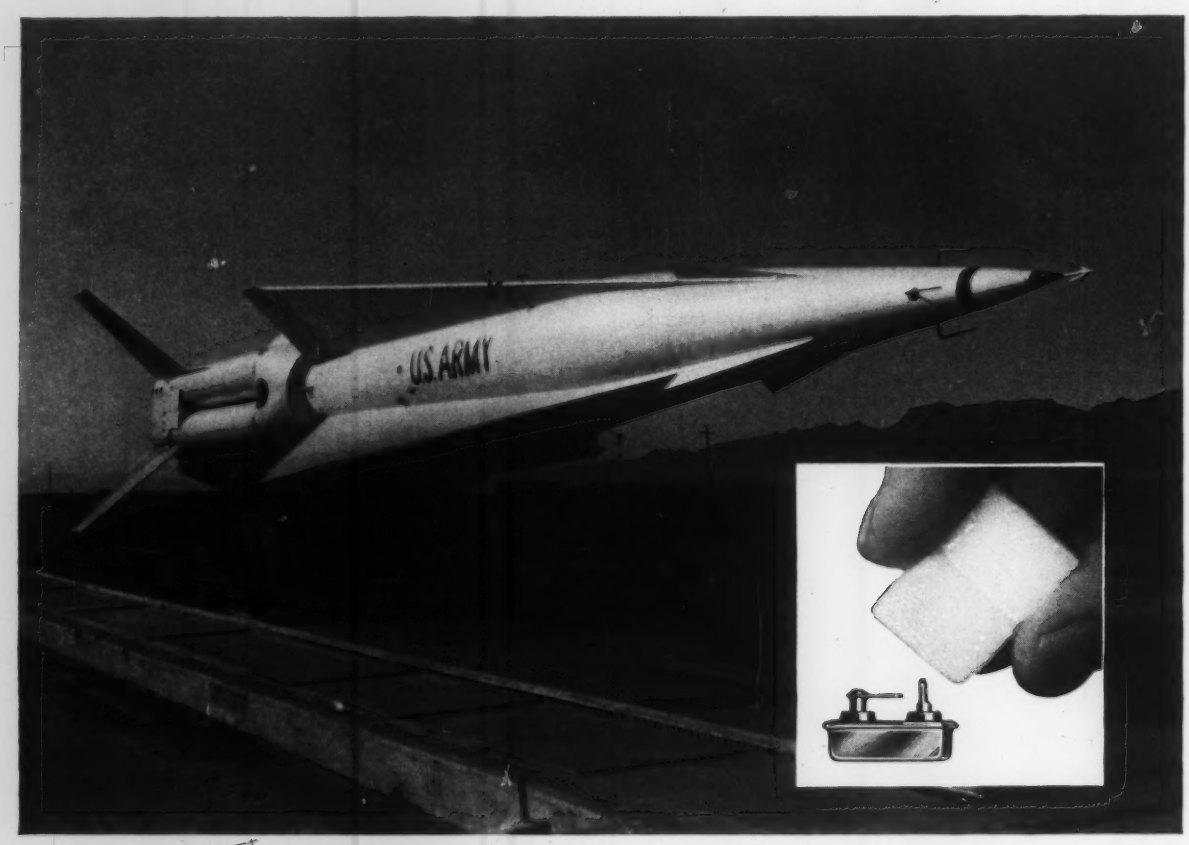
There'll be a hot time in the old ionosphere tonight. But with Fenwal's new Miniature Hermetically Sealed THERMOSWITCH Unit aboard everything will be under control. This tiny Fenwal unit responds quickly and accurately to temperature changes — *it's reliable!*

It's hermetically sealed, yet field adjustable. Even extreme vibration and shock won't upset its control characteristics — *it's built to take it!*

But most of all, this corrosion-resistant Fenwal unit does it all with exacting control of within 1° — in temperatures of −20°F to +200°F (−65°F to +220°F exposure limits). And it's the only unit that has all three features — *small size, ruggedness and precision control!*

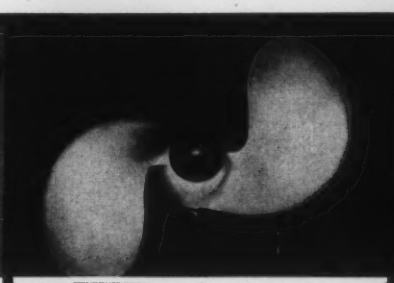
If missiles are your business you'll want all the information on this tiny, tough, sensitive and reliable control. For more information on this unit or complete Fenwal temperature control systems, write for our catalog. If you want, we'll send our sales engineer, too. Fenwal Incorporated, 1912 Pleasant Street, Ashland, Massachusetts.

The new Fenwal Miniature THERMOSWITCH Unit (compared here with a lump of sugar) weighs less than ¼ oz. Its current capacity is 2.5 amps, 115 VAC, 2.0 amps, 28 VDC. Widely used for crystal ovens, tuning forks, gyro assemblies, missile blankets and missile batteries.



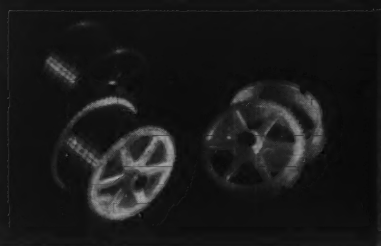
ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

SNAP-ON FASTENERS for accordion-door covers and quiet roller wheels are made of ZYTEL, which provides resiliency and resistance to impact and abrasion. (Molded by Flambeau Plastics Corp., Baraboo, Wis., for Hough Mfg. Corp., Janesville, Wis.)



OUTBOARD-MOTOR PROPELLER, made of Du Pont ZYTEL, is tough, durable and noncorrosive even in salt water. It adjusts its pitch automatically. Use of ZYTEL makes possible considerable cost savings. (By Grish Brothers, St. John, Indiana.)

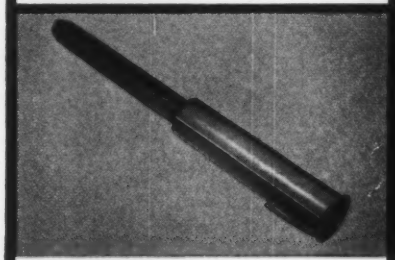
POWER-MOWER THROTTLE is molded of Du Pont ZYTEL 101 in several colors, taking advantage of this resin's toughness, wear resistance, chemical resistance and light weight. (By Western Control Corporation, Wichita, Kansas.)



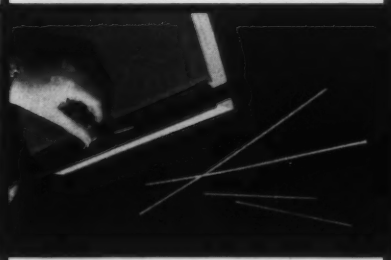
SPROCKET FOR TIME CLOCK has high strength, high fatigue-endurance limit, light weight. Injection-molded of ZYTEL, it cuts costs, simplifies assembly. (Molded by Hamilton Plastics Molding Co. for Cincinnati Time Recorder Co., both of Cincinnati, O.)

SPINNING REEL operates smoothly, is exceptionally light in weight, easy to handle and durable. Almost all parts are molded of Du Pont ZYTEL. (Molded by Plano Molding Co., Plano, Ill., for Waltco Products Incorporated, Chicago, Illinois.)

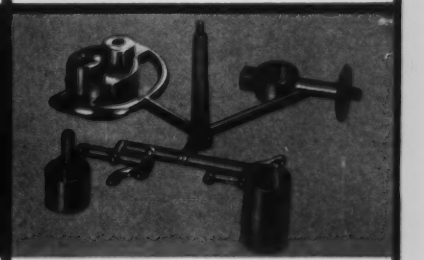
"SQUIRREL-CAGE" BLOWER is used in refrigerators. Made of Du Pont ZYTEL, this intricate, thin-walled molding has high strength, and is unaffected by the low temperatures encountered. (By Torrington Manufacturing Co., Torrington, Connecticut.)



SAND SPIKE fishing-rod holder is made of two parts of orange-colored ZYTEL. It is tough, corrosion-resistant and light in weight. (Molded by Du Bois Plastic Products, Inc., Buffalo, New York, for The Gliebe Co., Brooklyn, New York.)



POSTS for loose-leaf binders that hold business records are made of tough, flexible ZYTEL, easily threaded into holes. The posts permit greater sheet capacity, flatter opening than posts of other materials. (By Wilson Jones Co., Chicago, Illinois.)



AIR PUMP for aquarium has molded cap, bushings and cam actuator made of Du Pont ZYTEL. These parts offer high strength and abrasion resistance . . . make possible economies in production. (By Eugene Danner, Brooklyn, New York.)

Design advantages of ZYTEL® nylon resins demonstrated in wide variety of applications

Versatile ZYTEL nylon resins offer the designer a combination of properties that can be used to improve the performance and lower the cost of almost any mechanism. The high strength, abrasion resistance and low friction of ZYTEL make it an outstanding gear and bearing material. It is resistant to heat and chemicals. It can be economically injection-molded in intricate one-piece configurations, with moldings held to close tolerances. The result: reduction in inspection cost, material cost, fabrication cost.

Many molders have the experience to supply you with parts of ZYTEL nylon resin in quantity to your exact specifications. For your copy of a booklet, "Designing with ZYTEL nylon resins", write to: E. I. du Pont de Nemours & Co. (Inc.), Department V-12, Room 2507Z, Nemours Building, Wilmington 98, Del.

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

POLYCHEMICALS DEPARTMENT

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Circle 434 on Page 19

80-ton trailer hauls 5 times its own weight!

LeTourneau-Westinghouse designed this bottom-dump hauling unit to carry the greatest payload with the least possible empty weight. The trailer weighs only 15½ tons but will haul a whopping load of 80 tons or more. This gives it an extremely high ratio of payload to weight and makes the unit most economical on fuel, tires and other operating costs. The trailer differs radically in design from conventional units. Much of the body is built from USS MAN-TEN Brand High Strength Steel to save weight. Sides are corrugated ⅛-inch MAN-TEN having the equivalent bridge strength of ¾-inch carbon steel. Wear plates on the front and back slopes are 3/16-inch MAN-TEN to assure high resistance to abrasion and impact. The highly stressed rear-axle assembly was built with USS

Mr. Big hauls as much coal as 1½ railroad cars but weighs less than most 50-ton capacity trucks. USS Special Steels make the difference.

. . . built from USS MAN-TEN and USS "T-1" Steels

"T-1" Constructional Alloy Steel which has an extra high yield strength of 100,000 psi.

This combination produced a tough wear-resisting unit that would take the beatings from coal or rock. Both steels saved weight and resulted in a payload increase of 10 tons over conventional construction. In 21,000 miles of operation, no sign of structural weakness or body fault has been observed.

Design equipment with USS Special Steels . . . MAN-TEN for strength with economy, COR-TEN for strength with superior corrosion resistance, TRI-TEN for strength with toughness and "T-1" for extra high strength and impact abrasion resistance. For more information, write to United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

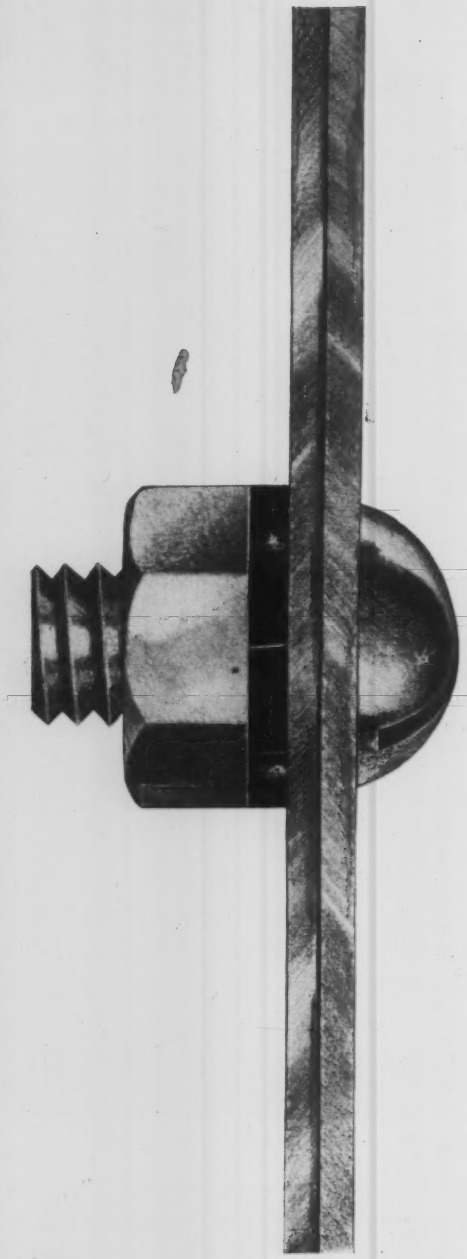
USS, MAN-TEN, COR-TEN, TRI-TEN and "T-1" are registered trademarks

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

USS

United States Steel Corporation – Pittsburgh
American Steel & Wire – Cleveland
Columbia-Geneva Steel – San Francisco
Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Supply – Steel Service Centers
United States Steel Export Company

United States Steel



WHERE TIGHTNESS IS VITAL

No substitute has ever been found for a quality, properly-engineered helical spring lock washer. No other device has ever been found to combat looseness in bolted assemblies caused by thread wear, metal stress or bolt elongation. Yet, an improperly fitted helical spring washer is little better than none at all. That is why, when you specify spring washers, you should be sure you are getting the particular size and type which will do the best job for you. To be sure, consult the Eaton-Reliance spring washer specialist whose business is helping you choose the right washer to do the job. Eaton-Reliance offers a full range of sizes and types for every application—and engineering service for every problem. Write for our special Spring Lock Washer Engineering Bulletin.

EATON

RELIANCE DIVISION

MANUFACTURING COMPANY

506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Los Angeles

PRODUCTS: Engine Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Hydraulic Pumps Truck and Trailer Axles • Truck Transmissions • Permanent Mold Iron Castings • Automotive Heaters and Air Conditioners Fastening Devices • Cold Drawn Steel • Stampings • Forgings • Leaf and Coil Springs • Dynamatic Drives and Brakes Powdered Metal Parts • Gears • Variable Speed Drives • Speed Reducers • Differentials • Centralized Lubrication Systems

Some Ideas

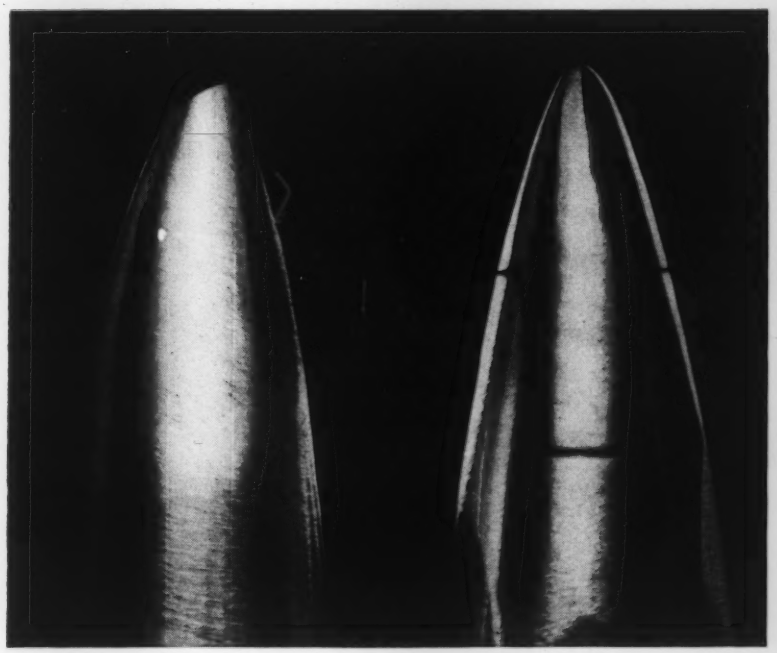
for your file of practical information on drafting and reproduction from

KEUFFEL & ESSER CO.

It seems that today's rugged drafting films, such as K&E Herculene and Stabilene, can dish out punishment as well as take it. Smooth and comfortable as they are to work with, these films can blunt the points of some ruling pens after about 80 hours of drafting – though their effect on pencils is no more abrasive than any other material. For pen-and-ink work on Mylar-based films, K&E offers a simple solution . . .

Tough Pens for Tough-Toothed Films

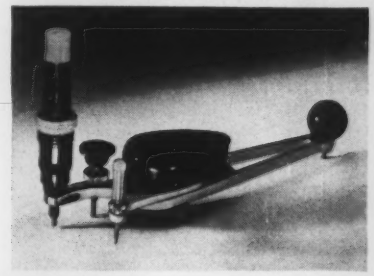
Two new K&E drawing instruments – the Paragon® Drop Bow Pen No. 813H and the Paragon Bow Pen No. 816H – are now part of the well-known Paragon *Red Tip* line. Both are pointed with Carboloy, hardest of metals. The Carboloy insert, butt-welded to the pen's blades, forms a tip that resists the subtly abrasive film, keeps its shape for hundreds of hours of neat, sharp, almost effortless inking.



Wearing power of new Carboloy-tipped K&E ruling pens was dramatically proved in a recent test series by a governmental agency. Results of our own tests are shown above. At left: plain steel tip after tracing 500 feet on Mylar®-based Herculene® Film. At right: Carboloy point of Paragon *Red Tip* pen after 5,000 feet – about a year's work – on the same material. If you'd like to see a more detailed report, we'll gladly send it to you, on request.

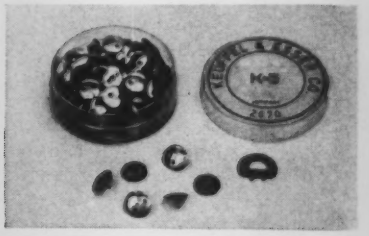
Days Between Refills

You can letter continuously – for remarkably long periods – without refilling the new Leroy® Reservoir Pen by K&E. Its



airtight cartridge – made of non-porous, transparent plastic – holds a liberal supply of your favorite waterproof India drawing ink. This pen is self-cleaning – fitted with a tiny weighted needle in the feed tube. If the pen has been idle for an hour or so, simply shake it lightly and vertically to actuate the needle, break up and remove any particles which may have settled in the passage. Smooth ink flow resumes immediately. You'll find the needle's efficient mechanical cleansing action helpful when washing the pen, too.

The Leroy Reservoir Pen (No. 3230) comes in seven sizes, 00 to 5. The points are specially designed for vertical use: when held in Leroy Scribers, these pens glide easily over paper or film surfaces, produce sharp, crisp, uniform lettering that reproduces beautifully. Leroy Reservoir Pens are available individually or in sets of seven (No. 3230S). A new K&E brochure gives full details. Ask us for it, today.



Easing A Sticky Situation

Do you sometimes have a tack-up problem where sticky adhesives don't do the job? Then maybe you need a good thumbtack (almost a forgotten item in the draftsman's kit). But K&E still has thumbtacks, and they are the best you can buy. They're made of nickel-plated steel, and have thin, streamlined heads that permit drafting machines to slide easily over them.

From thumbtacks to lumber crayons, there are a thousand and one other items almost forgotten, perhaps, but which K&E carries to serve every draftsman's need – as infrequent as that need may be.

Your nearby K&E dealer will be pleased to demonstrate these helpful drafting room items. Stop in and see him, or clip and mail the coupon below for more information.

Herculene, Stabilene, Paragon and Leroy are registered trademarks of Keuffel & Esser Co.

KEUFFEL & ESSER CO., **Dept. MD-12, Hoboken, N. J.**

I'd like to know more about:

- ☐ New K&E Paragon Ruling Pens with long-wearing Carboloy tips.
- ☐ New K&E Leroy Reservoir Pen.

Name & Title_____

Company & Address_____

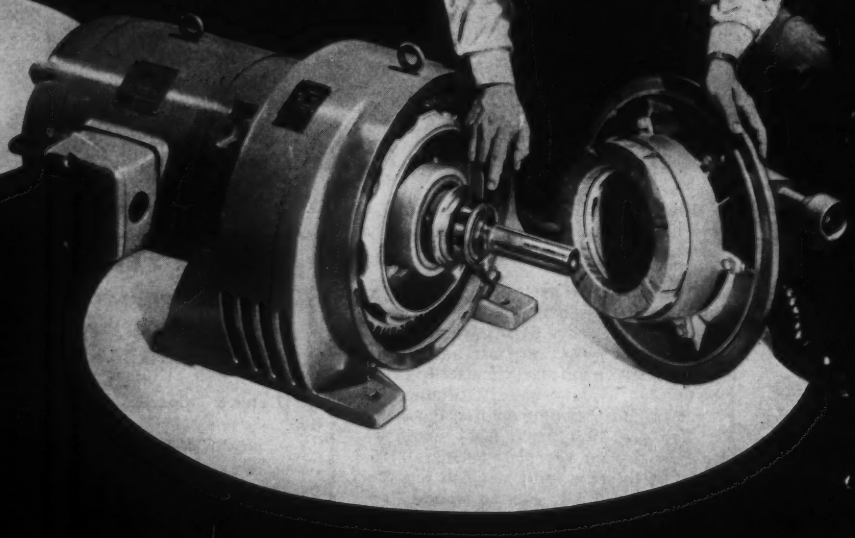
_____ 2003

What do you need in an adjustable speed drive?

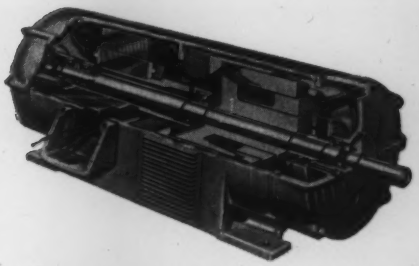
Better Regulation!

Compactness!

Less Maintenance!



7½-hp Ajusto-Spede Drive



Common motor-drive housing for units up to 7½ hp saves space — can be foot or flange mounted. Larger sizes up to 100 hp with individual motor and drive housings mounted integrally.

NEW design news from Louis Allis

...The Louis Allis AJUSTO-SPEDE® drive is more compact, precise, and trouble-free

Here's an adjustable speed drive that allows *truly precise* machine operation. Speed regulation is automatic and stepless — results in faster, more efficient production at lower cost, with less waste, and minimum wear on equipment.

These and other benefits are yours when you use the improved Louis Allis Ajusto-Spede drive. For example, it can be set before or during operation to deliver any desired speed within its range. Its *exclusive* tachometer feedback circuit monitors the output speed and *automatically corrects speed and holds it* regardless of load changes.

This improved drive requires minimum maintenance. Its stationary field has no brushes, commutators, or slip rings to cause trouble. The source of power is an equally trouble-free standard a-c squirrel cage motor. The cast-iron housing keeps out dirt, chips, and moisture — resists corrosion.

The compact Ajusto-Spede also saves space. Integrally-mounted motor and drive simplify handling — can be easily adapted for installation on new or existing machines. Controls can be mounted at the machine or any other convenient position.

The Louis Allis Ajusto-Spede drive is the practical solution to almost every application that requires dependable, easily controlled adjustable speed. It is the answer to precise operating speeds for machine tools, process machinery, test equipment, windups, conveyors, printing presses, and other equipment. Contact your Louis Allis District Office for information and application help. Or write for bulletins 2750 and 2800 — The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

® *Ajusto-Spede is a registered trademark of the Eaton Mfg. Co.*

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

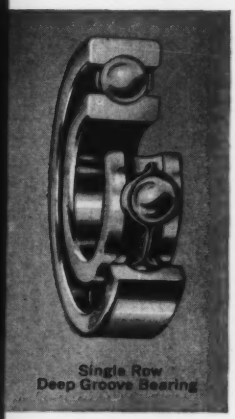
LOUIS ALLIS

ASD-127

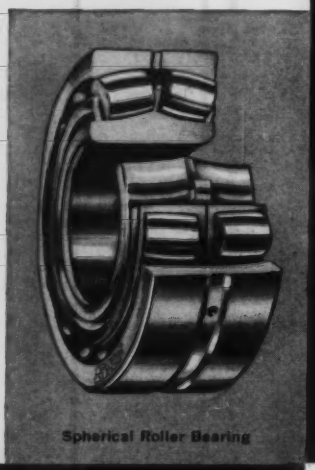
Circle 437 on Page 19

What's "special" about these standard SKF bearings?

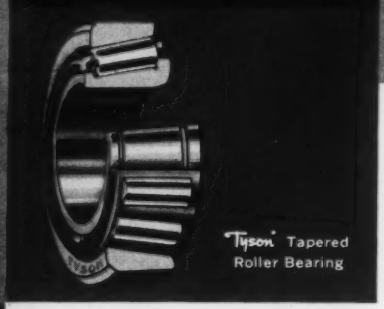
*Cylindrical Roller Bearing



Single Row Deep Groove Bearing



Spherical Roller Bearing



"Tyson" Tapered Roller Bearing

Spherical Roller Thrust Bearing

Angular Contact Bearing

They all have exclusive features. Where else, for example, can you get the 33⅓% higher capacity available in standard SKF spherical roller bearings?

*Or, take the cylindrical roller bearing. This type provides high radial capacity and minimum shaft friction. Controlled shaft end float within the bearing is a natural advantage of this design.

Yet this is SKF's standard cylindrical roller bearing, promptly available in 154 sizes ranging from just under 1" to 6" (bore). In the double row it's 1" to 9.5".

Why not get the complete facts on these "special" but standard (and economical) bearings? For details, call any of the 25 SKF sales offices today. 5923

Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE—EVERY USE

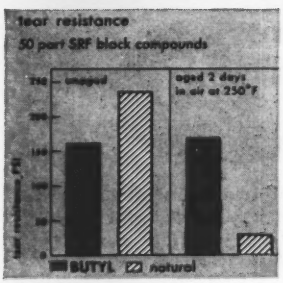
SKF®

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U. S. PAT. OFF.

ENJAY BUTYL

RUBBER FOR RESISTANCE TO TEAR AND ABRASION



Enjay Butyl offers the highest aged tear strength of any rubber. Even after long exposure to heat, oxygen and ozone, Butyl retains nearly all its original tear and flex resistance...keeps its stretch without tearing. And Butyl's inherent toughness offers rugged resistance to abrasive wear. Butyl is the preferred rubber and proven superior in such applications as conveyor belts, hoses, heavy-duty off-the-road truck tires, and other mechanical goods.

Butyl also offers...outstanding resistance to chemicals, weathering, sunlight, heat, and electricity...superior damping qualities...unmatched electrical properties and impermeability to gases and moisture.

Find out how this versatile rubber can improve your product. Call or write the Enjay Company, today!

ENJAY BUTYL

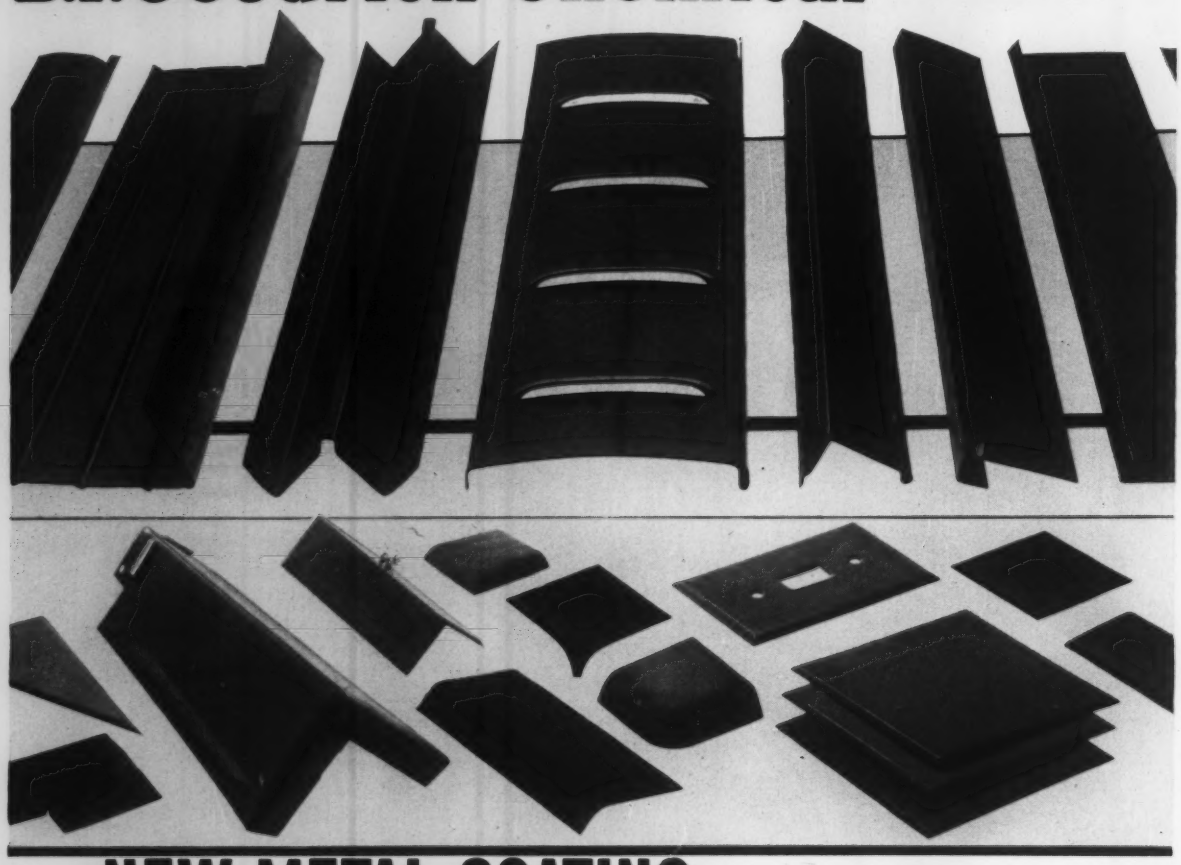
EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N.Y.*

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

Another new development using

B.F.Goodrich Chemical *raw materials*



NEW METAL COATING USING GEON...CUTS FABRICATING COSTS

Before they were shaped or formed, bent or punched, each of the parts shown above was coated with a new enamel-type coating made with Geon polyvinyl material. The coating was done while the metal was flat in one piece—the easy way. Each manufacturing operation proved again the unusual punishment the Geon coating can take—there is no effect on appearance or performance.

Geon makes the coating tough and durable. It will last far beyond normal expectations. In fact, after thorough tests, one manufacturer determined it could be safely warranted for ten years—even when his product is used outdoors exposed to the elements—against crazing, cracking or blistering.

Geon also gives a coating superior abrasion, electrical and chemical resistance. It contributes these and other advantages in other products, too, such as moldings, extrusions, foam or sheet. Get more information by writing Dept. AS-6, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

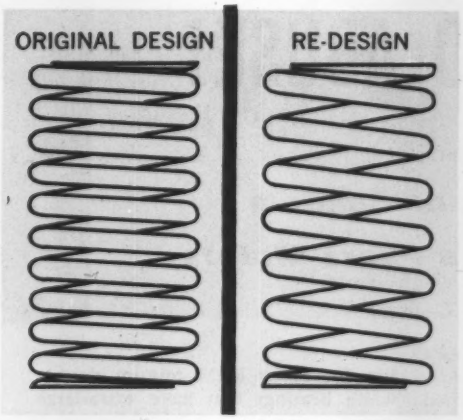
B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

70 POUNDS OF SPRINGS

were just going along for the ride!



10 coils—.120″ wire
130 lbs. of wire per
1M springs

7 coils—.105″ wire
60 lbs. of wire per
1M springs

Because of mounting cost conditions, a user of motor-support springs asked for a complete design check. Redesigned by A.S.C. engineers, required stresses were met by a slight change in wire size, allowing a reduction in number of coils from 10 to 7. This meant a saving of 70 pounds of material per thousand springs. Because of the shorter length of wire, coiling and grinding speeds were increased, heat-treating time reduced. Saving to the customer—40%.

How about the springs you use? A consultation on your specifications costs you nothing. Just contact any Division of Associated Spring Corporation. For a handy reference to spring action, write for "Spring Design and Selection—in brief."

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
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Seaboard Pacific Division, Gardena, Calif.
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Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que. Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.

Circle 441 on Page 19

Motors Thrive on FREQUENT OVERLOAD ABUSE!

Brunswick D-31 Precision Bowling Lane Sanders

Powered by Lightweight R&M 8 HP Single Phase Motors

The Brunswick-Balke-Collender Company recently handed ROBBINS & MYERS an unusual motor problem when it re-powered the Brunswick D-31 precision bowling lane sander. The D-31 cuts across 250 square inches of area in one continuous cutting operation. Motor must withstand frequent and severe overloads when the machine levels high spots in the alley bed. Power had to be single-phase, too, because many bowling establishments carry only single phase current! To keep sander truly portable and easily maneuverable . . . and to protect lanes from excess weight, motor had to be lighter than ordinary single-phase motors.

ROBBINS & MYERS custom-designed an 8 HP capacitor-start, capacitor-run motor that is daily proving its stamina against these rugged requirements. Should more power be needed, design includes provision for adding an auxiliary blower which can conveniently increase capacity to 10 HP. Weight was kept down by using special aluminum end heads. For easier maintenance, the extended end-head housing can be removed quickly and easily to expose condensers and centrifugal switch.

Many other features insure longer life for *every* R&M motor: double width bearings that have extra-large grease capacity . . . Mylar* insulation with 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . removable caps for quick bearing inspection and relubrication . . . end heads that give full-height protection . . . dual-sweep ventilation for efficient cooling.

For motors to meet unusual challenges . . . and for standard motors, always contact ROBBINS & MYERS! Write today for Bulletin 470-MD

**DuPont registered trademark*

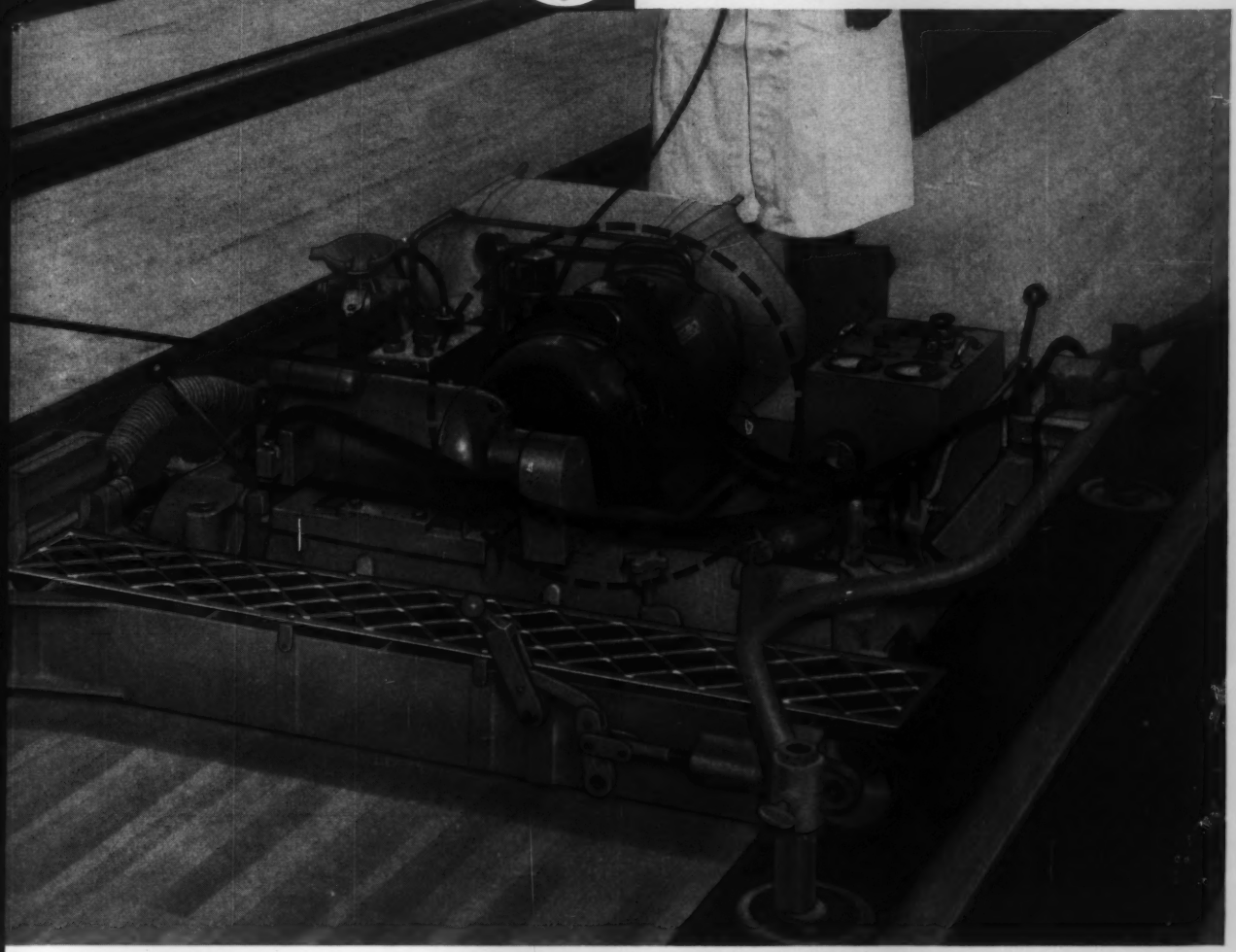
ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

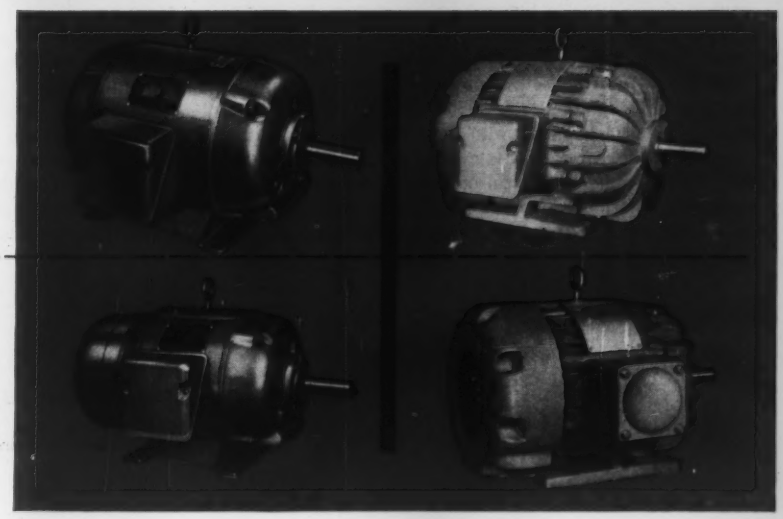
MOTORS 1 thru 200 HP

(other ratings 1/200 to 1 horsepower)



Open Protected Motors (left), up to 200 HP, are suitable for many applications formerly requiring totally enclosed construction.

Totally Enclosed Motors (right), ½ to 200 HP, are fan-cooled . . . offer complete protection against all harmful atmospheres.



"PM" Single Phase Motors (left), ratings through 20 HP, eliminate maintenance because they are fully weatherized for severe duty.

Explosion-Proof Motors (right), ratings through 200 HP, are Underwriters' Approved for Class I, Group D, and Class II, Groups F & G.

Circle 442 on Page 19

WHO MAKES FINE MOTORS THIS SMALL?

Globe Industries makes motors this small to make your design more compact, reliable and salable. If you make miniature instrument packages for space exploration — if you build airborne and ground support equipment — if you want to design smaller typewriters, computers, recorders or other products, look at these 3 motors:

TYPE VS—The smallest, most powerful precision miniature d.c. motor for its size. Only 7/16" flat, four VS motors fit in a regular cigarette pack with room to spare. It has the power to lift its own weight to the top of the Empire State Building in 1 minute! Typical continuous torque—.25 oz. in.; typical intermittent torque—.5 oz. ins. We can design gear units, governors and brakes to meet MIL specs also.

TYPE SS — Only 7/8" in diameter, Type SS d.c. motors typically produce continuous duty torques of .3 oz. in.; intermittent torques to .6 oz. ins. With the basic Type SS motor you can specify any of 21 planetary gear speed reducers or 28 spur gear speed reducers. Governors and brakes are available also. Designed to meet MIL specs.

TYPE MM — The most widely used precision 1¼" d.c. motor in the world, MM motors typically produce .5 oz. in. in continuous duty applications — 1.0 oz. in. intermittent duty. Choose from 101 ratios of planetary gear speed reductions. Brakes, governors and clutches can be included. MIL specs are invited.

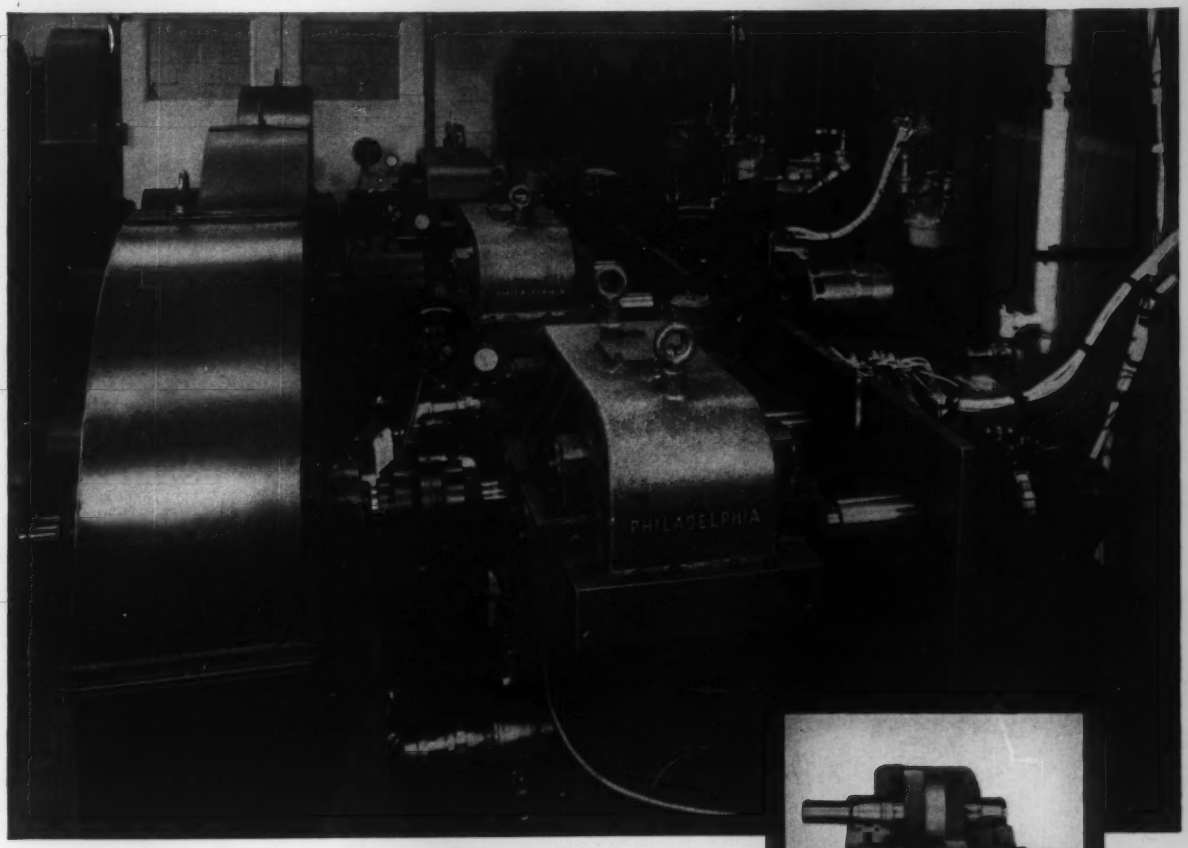
For details about these motors request Bulletin VSM Globe Industries, Inc., 1784 Stanley Ave., Dayton 4, Ohio

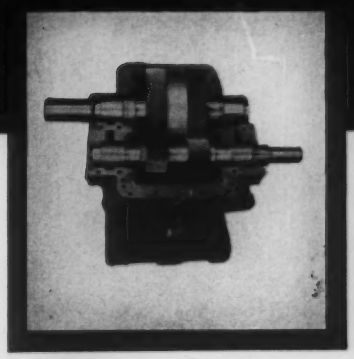
GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, GYROS, STEPPERS, BLOWERS, MOTORIZED DEVICES

GLOBE

Circle 443 on Page 19





PHILADELPHIA HI-SPEED INCREASERS drive simulated "test flight on ground"...

Testing of jet aircraft electrical power systems calls for exact duplication of tortuous flight conditions in the lab . . . *complete to supersonic speeds!* At General Electric Aircraft Systems Engineering Laboratory above, three Philadelphia speed increasers drive generators for simulating conditions of both low inertia, high acceleration reciprocating engines and high inertia, low acceleration jet engines. Each stand is powered by a 200 HP DC motor coupled to a Philadelphia 5.8:1 speed increaser. The drive system provides for adjustable speed at rated continuous power from 4000 to 12000 rpm with overload capacity of 300 HP for five minutes and 400 HP for five seconds.

To meet these exacting requirements for performance and continuous operation, Philadelphia HI-SPEED drives offer exclusive advantages in drive design . . . advantages you can't get anywhere else. Double opposed helical gearing is precision hobbed, precision tooth ground and dynamically balanced. Symmetrically arranged gearing balances loads on bearings and shafts. Shaft deflection is minimized . . . bearings last longer.

Philadelphia HI-SPEED Drives are available in standard units for speeds to 10,000 rpm at pitch line velocities to 10,000 fpm. 1 to 7100 HP. Ratios from 1:1 to 10:1 for high speed reduction or increase. Special HI-SPEED drives are furnished for higher speeds, horsepowers and ratios. Write today for your copy of our HI-SPEED catalog.

PHILADELPHIA GEAR CORPORATION
Erie Avenue and "G" Street, Philadelphia 34, Pennsylvania

philadelphia gear drives

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

Circle 444 on Page 19

New Century Electric motor starts on 50% less current

Here is the answer to power company limits on starting current for *single phase* motors . . . a new Century Electric capacitor-start motor with a really low starting current. In the 20 hp size the *starting* current is 220 amps . . . as low as that for a normal 10 hp motor.

Applications — This capacitor-start, capacitor-run motor provides dependable starting and operating power for crop dryers, large irrigation pumps, hay dryers and machines started on an open clutch. Because of the high cost of running three phase power to isolated areas, most utilities prefer to supply single phase power . . . and this new motor means that users can have sufficient single phase horsepower for this type of equipment.

Specifications — You can get this new Century Electric motor in 7½ to 20 hp sizes. It is available in 1200 and 1800 rpm speeds at 230 volts. Totally-enclosed, drip-proof and explosion-proof enclosures are also available. Mounting dimensions are shown on the chart below.

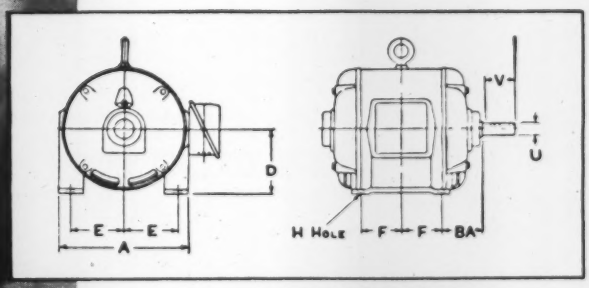
Design features — Wire insulation on the new Century Electric CPF motor is vinyl acetal resin . . . slot cell insulation is bonded "Mylar" . . . combination gives tough mechanical protection, high dielectric strength and resistance to moisture. Motor is smooth and quiet running because of rigid cast iron frame. Rotor lamination is skewed for smooth start and quiet operation. High pressure aluminum casting gives rotor winding bars high density. Capacitor box comes in separate weather-protected enclosure . . . means it can be mounted conveniently next to control device or wherever space can be best utilized.

For more information on this new capacitor motor contact your nearest Century Electric Sales Office or Authorized Distributor. For detailed information on motor applications write for the new Century Electric Motor Application Guide . . . bulletin 270A.

CENTURY ELECTRIC COMPANY

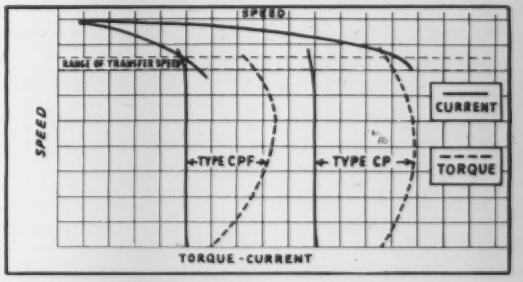
St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Century 59-11



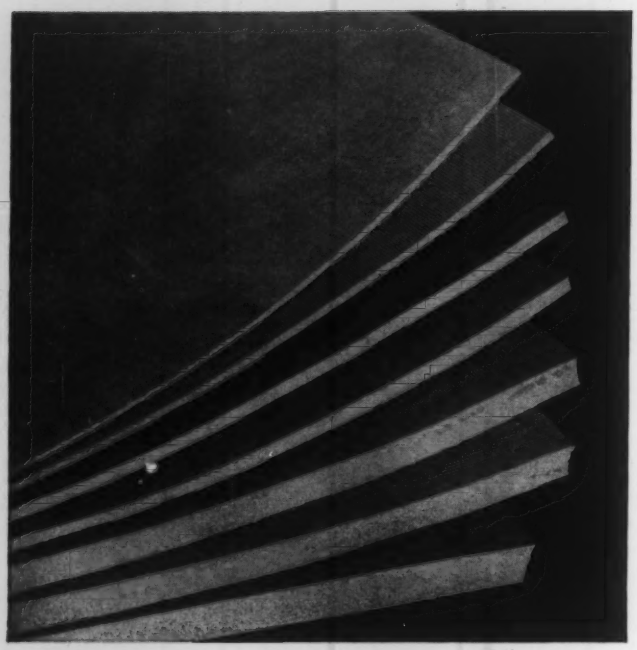
MOUNTING DIMENSIONS
for new Century Electric capacitor-start motor.

Frame Size	Key	A	BA	D	E	F	H	U	V
256U	5/16x5/16	12½	4¼	6¼	5	5	11/32	1⅜	3½
284U 286U	⅜x⅜	14	4¾	7	5½	4¾ 5½	11/32	1⅜	4⅝
324U	½x½	16	5¼	8	6¼	5¼	21/32	1⅛	5⅜



TYPICAL SPEED-TORQUE curves for Century Electric Type CPF motor, compared with standard Type CP unit of similar capacity.

Circle 445 on Page 19



Silicone Sponge Rubber

remains flexible at extreme temperatures
−100° F to 500° F

COHRlastic R-10470 silicone sponge rubber has a dense, uniform, non-absorbing closed cell structure, highly suitable for soft gasketing, vibration dampening, fairing strips, seals, pads, bumpers, dynamic cushions and other applications where resiliency at extreme temperatures is required. It has superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening and good chemical resistance — non-sticking, odorless, non-corrosive.

COHRlastic R-10470 can be bonded to metals, plastics, fabrics or silicone rubber. Sheets 24″ x 24″ and in thicknesses 1/16″ through 1/2″ are available from stock. Larger sizes up to 30″ x 30″ and special molded and extruded shapes are made to order. CHR silicone sponge rubber is sold nationally through distributors.

FREE SAMPLES and folder — write, phone or use inquiry service.

CHR

COHRlastic R-10470
Silicone Sponge Rubber

SPECIFICATIONS:

COHRlastic R-10470 meets many specifications. Some are listed below:

AMS 3195
AMS 3196
MIL-R-6130A type 2
Boeing BMS 1-23
Martin MC1 4546
Martin MB 6130
Bendix ES 0709
Douglas DMS 1597
Lockheed LAC 1-924

PROPERTIES	Range of typical properties COHRlastic R-10470	Typical accepted standards
Tensile	50-130 psi	40 psi, min.
Elongation	175-225%	125% min.
Water absorption (Immersion 24 hrs. @ 75°F.)	3-6%	10% max.
Density, lbs./cu. in.	.020-.030 (firm)	.030 max.
	.013-.018 (medium)	.020 max.
Low temperature brittleness (5 hrs. @ −100°F., bend flat)	No cracking	No cracking
Compression deflection (compressed to 75% of original thickness)		
Room temperature		
Type firm	12-18 psi range[1]	12 min.-20 max. psi
Type medium	8-14 psi range[1]	6 min.-14 max. psi
−65°F. pct. difference	−10% to +15%[1]	
212°F. pct. difference	+5% to +10%[1]	
Compression set (compressed to 50% of original thickness)		
22 hrs. @ 70°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ −65°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ 212°F	10-25% (firm)[1]	30% max.
	20-50% (medium)[1]	60% max.

1 ASTM D 1056-56T

CHR products include:

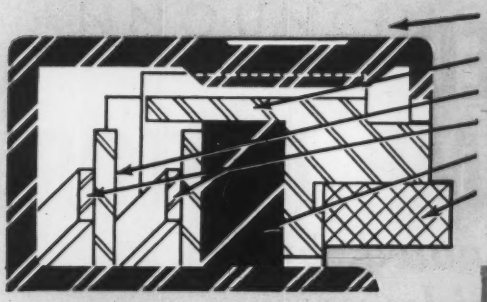
COHRlastic Aircraft Products — *Airframe and engine seals, firewall seals, coated fabrics and ducts*
COHRlastic Silicone Rubber Products — *Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber*
Temp-R-Tapes — *Pressure sensitive, thermal curing Teflon and silicone tapes*
Allied Products — *COHRlastic silicone cements and conductive gasketing*

CHR Leader In Fabrication of Silicone Rubber

CONNECTICUT HARD RUBBER COMPANY

Main Office: New Haven 9, Connecticut

GITS HH-TYPE SEAL SERIES



VITON "A"

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

Circle 447 on Page 19

GITS

Extra Flexibility For Your Seal Applications!

ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

Use of this one standard Gits HH-type seal envelope — with your choice of the five seal packing arrangements illustrated at left — permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements.

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information

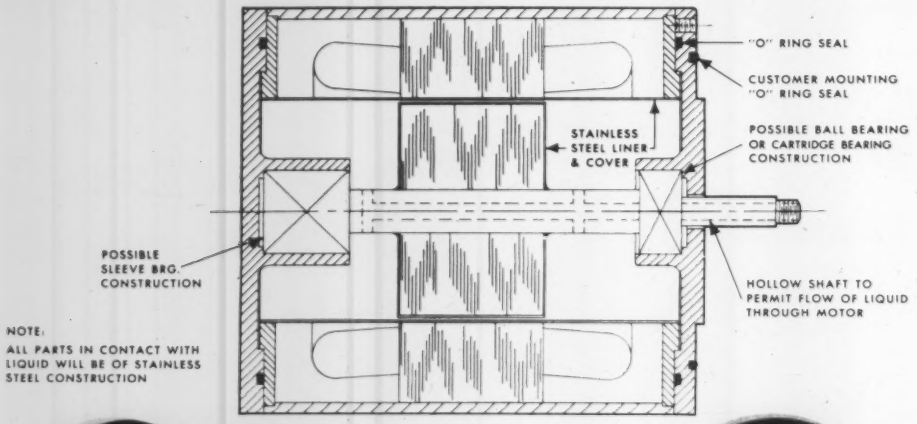
GITS BROS. MFG. CO.

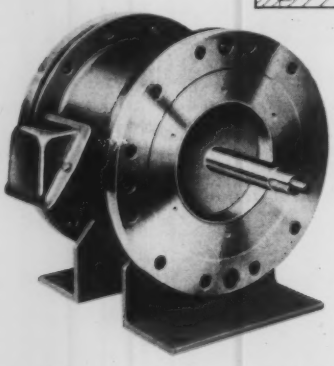
1868A South Kilbourn Avenue • Chicago 23, Illinois

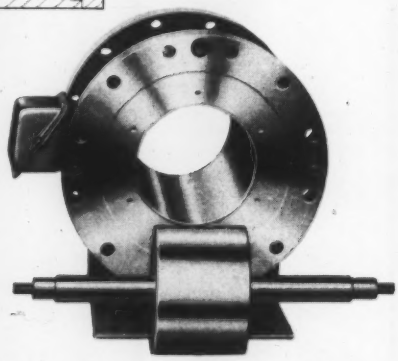
NEW! *Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.*

COMPLETELY SEALED STAINLESS PUMP MOTOR

for handling nuclear contaminated, highly corrosive or highly volatile fluids


"O" RING SEAL
CUSTOMER MOUNTING "O" RING SEAL
STAINLESS STEEL LINER & COVER
POSSIBLE BALL BEARING OR CARTRIDGE BEARING CONSTRUCTION
POSSIBLE SLEEVE BRG. CONSTRUCTION
HOLLOW SHAFT TO PERMIT FLOW OF LIQUID THROUGH MOTOR
NOTE:
ALL PARTS IN CONTACT WITH LIQUID WILL BE OF STAINLESS STEEL CONSTRUCTION





This stainless steel, canned motor in ½ HP to 5 HP sizes follows NEMA specifications for the next higher horsepower at the same motor speed. Bearing type and material depend on the liquid being pumped. Stainless ball bearings, carbon block, glass, teflon, sintered bronze, teflon impregnated bronze and other materials can be used.

Liners and covers are all welded to form a perfect seal over each welded surface. End brackets are attached with "O" ring seals.

The motor can be submerged, but doesn't have to be. All units are special construction.

Our engineers will work with you on your applications.

PEERLESS ELECTRIC DIVISION
W. MARKET ST.

PORTER

H. K. PORTER COMPANY, INC.
WARREN, OHIO

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION, PEERLESS ELECTRIC DIVISION; Specialty Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S. A., and in Canada, Refractories, "Disston" Tools, "Federal" Wire and Cable, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

ANNOUNCING A NEW OXIDATION RESISTANT

GRAPHITAR®

(CARBON-GRAPHITE)

FOR HIGH TEMPERATURE APPLICATIONS

Culminating five years of intensive research, engineers of The United States Graphite Company have developed a new oxidation resistant GRAPHITAR. In exhaustive tests, GRAPHITAR parts were exposed in an oxidizing atmosphere (air) at 1200 degrees F and after 200 hours, the GRAPHITAR showed a weight loss of less than six percent!

GRAPHITAR, which is available in many grades, is a versatile engineering material with unusual and outstanding properties that make it ideal for tough applications. It is non-metallic, resists chemical attack, has self-lubricating properties and a low coefficient of friction. It is mechanically strong, lighter than magnesium and is the perfect material for packing rings, pressure joint seals, clutch release bearings, fluid coupling seals, piston rings, pump liners and vanes.

For more information on this new oxidation resistant GRAPHITAR and its applications, write the GRAPHITAR product manager on your company letterhead.

R-279-1

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

General Electric Announces Newest In The Complete Line Of Adjustable-Speed Drives

PARMATIC SPEED VARIATOR... newest in General Electric's complete line of packaged adjustable-speed drives . . . provides greater machine flexibility, better quality control, higher output and efficiency.

STATIC POWER

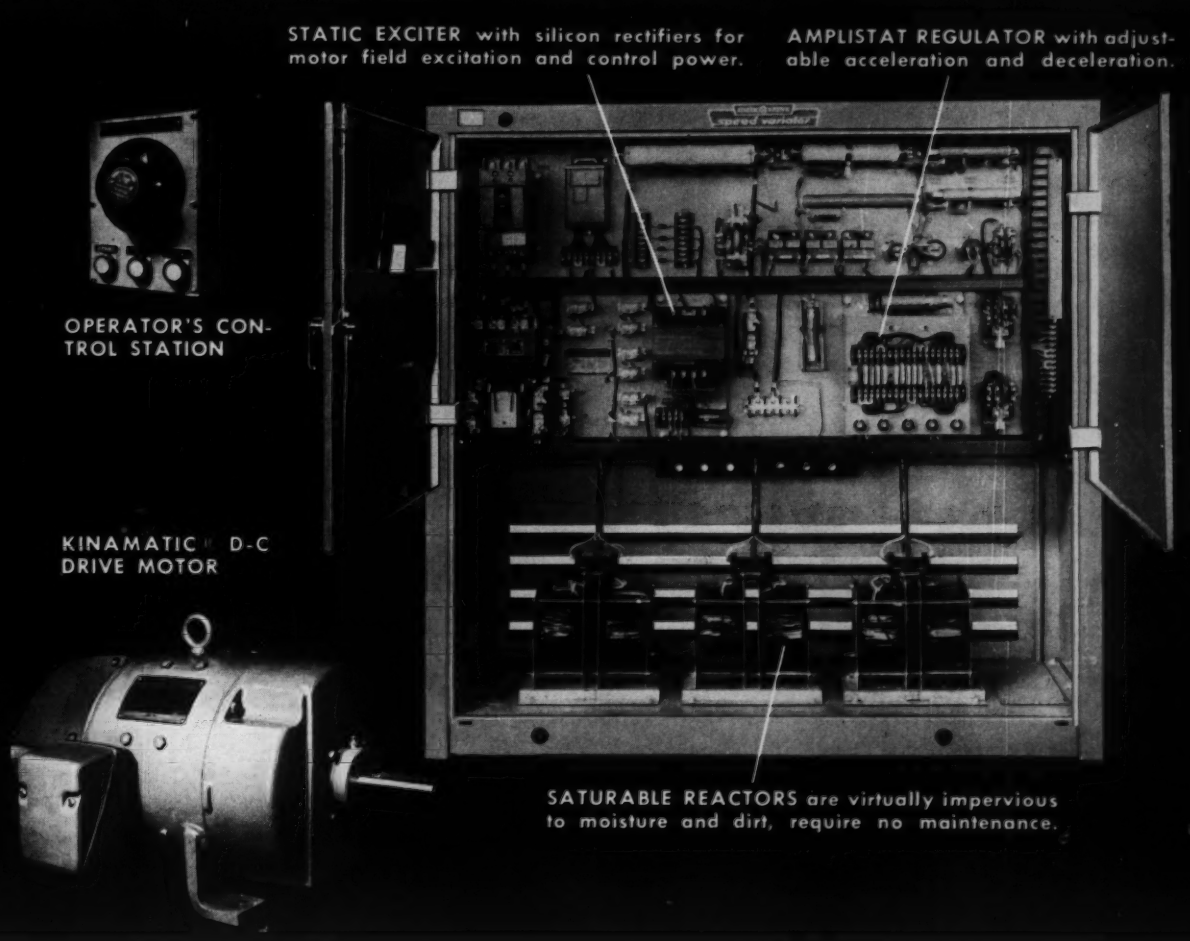
for less maintenance, less downtime, added profit. New excitation and power conversion systems have no rotating parts. Sealed silicon rectifiers and saturable reactors need no warm-up, virtually eliminate power unit maintenance.

25% SMALLER

for easier installation. Reliable, long-life G-E components are factory assembled in compact, space-saving power unit, wired and tested before installation to assure accurate control, reduced installation time and expense.

50% LIGHTER

for lower shipping and handling costs. New Speed Variator meets industry's demand for lighter, more powerful drives—packs more power, weighs 50% less than other drives of comparable rating, 2000 lbs less in 100-hp ratings.


STATIC EXCITER with silicon rectifiers for motor field excitation and control power.
AMPLISTAT REGULATOR with adjustable acceleration and deceleration.
OPERATOR'S CONTROL STATION
KINAMATIC® D-C DRIVE MOTOR
SATURABLE REACTORS are virtually impervious to moisture and dirt, require no maintenance.

FIELD PROVEN

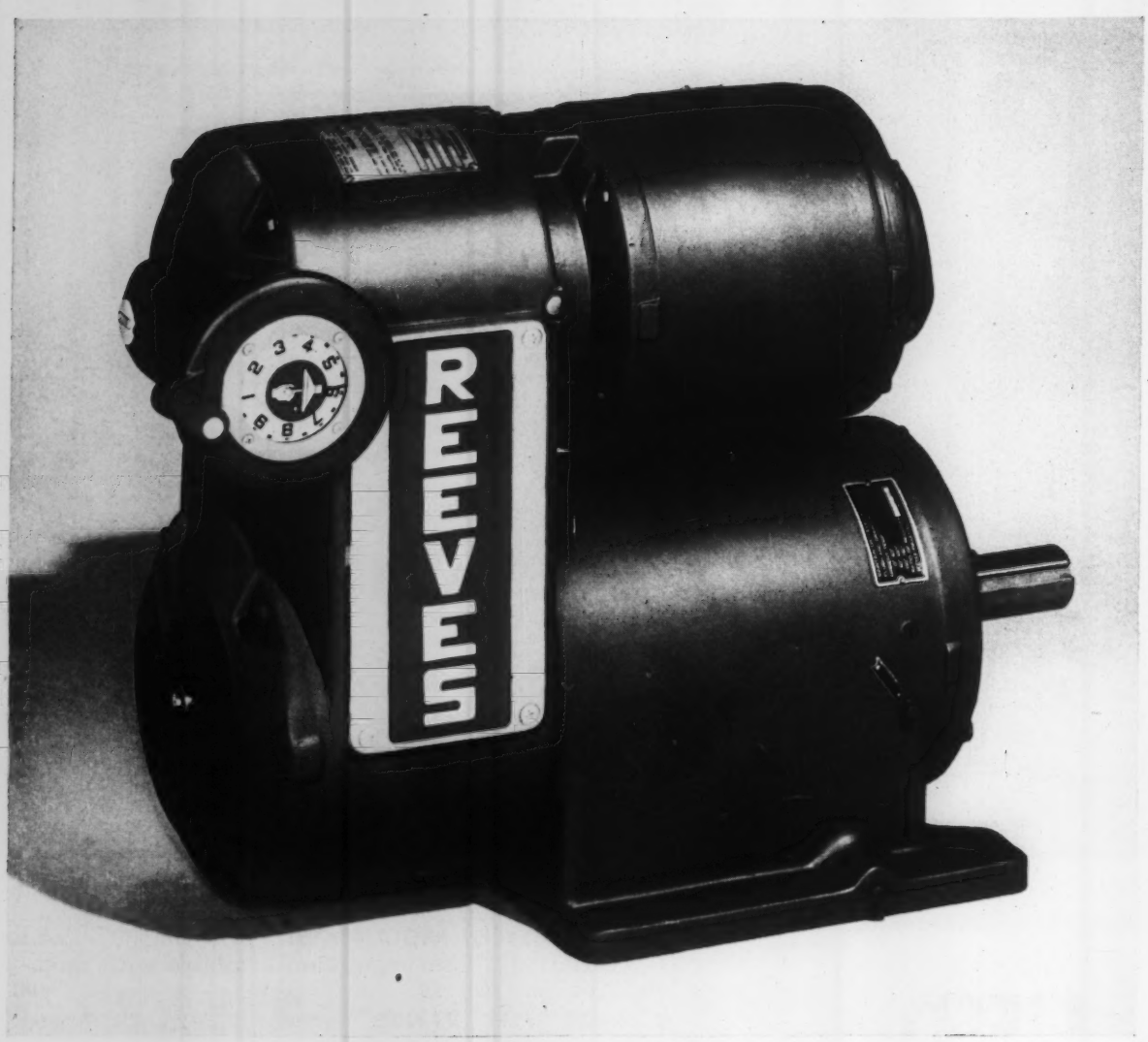
by two years' impressive on-the-job performance in several hundred installations in 15 industries. Experience indicates high operating efficiency, lower cost installation and maintenance for a greater return on your investment.

- **GOOD SPEED REGULATION:** 5% with 100% load variation. Closer regulation available with modification.
- **WIDE SPEED RANGE:** Standard Parmatic Speed Variator provides 8 to 1 range or wider if required.
- **RESISTS CONTAMINATION:** Saturable reactors and hermetically sealed rectifiers resist dirt and moisture.
- **QUIET AND VIBRATIONLESS:** New power unit design eliminates noise and vibration—expands drive versatility.

Limitations: G-E Kinamatic Speed Variator with motor-generator set is recommended for applications requiring power absorption for stopping or overhauling loads. *For more information*, call your General Electric Sales Engineer, or write for GEA-7012, Section 821-1, General Electric Company, Direct Current Motor and Generator Department, 3001 East Lake Road, Erie, Pennsylvania.

GENERAL ELECTRIC

Circle 449 on Page 19



REEVES Vari-Speed Motodrive

packed with new flexibility . . . broader production use

Now available in this compact design, Reeves Vari-Speed Motodrives deliver 2:1 through 10:1 speed variation, 1.8 through 4660 rpm . . . ¼ to 20 hp.

The infinitely variable output speeds meet almost every production need.

You can get these drives with output shaft on same or opposite side of the motor; vertical, 45°, horizontal or trunnion models; no reducer, and single, double or triple stage reductions . . . hundreds of space saving assemblies. Reeves provides a full range of modifications, accessories, and manual, remote or automatic controls. G-1639

Write today for complete data on sizes 100-500 (¼-20 hp) and sizes 8000 (25-40 hp)

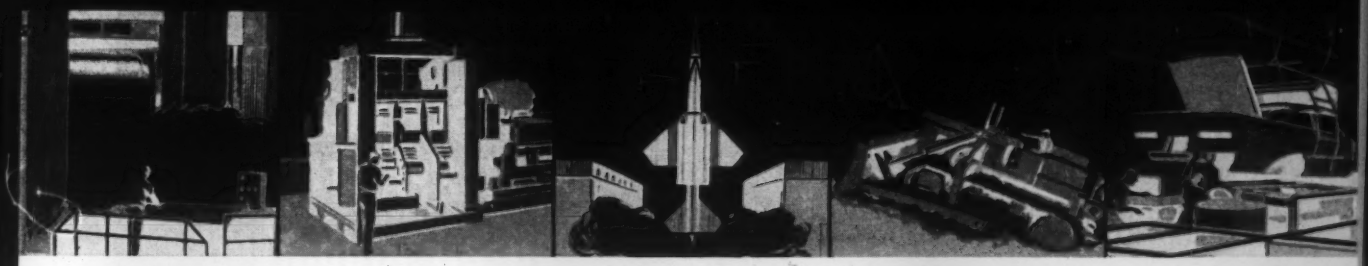
REEVES PULLEY COMPANY
Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.
COLUMBUS, INDIANA
In Canada: Reeves Drives • Toronto • Montreal

R MASTER
REEVES

Circle 450 on Page 19

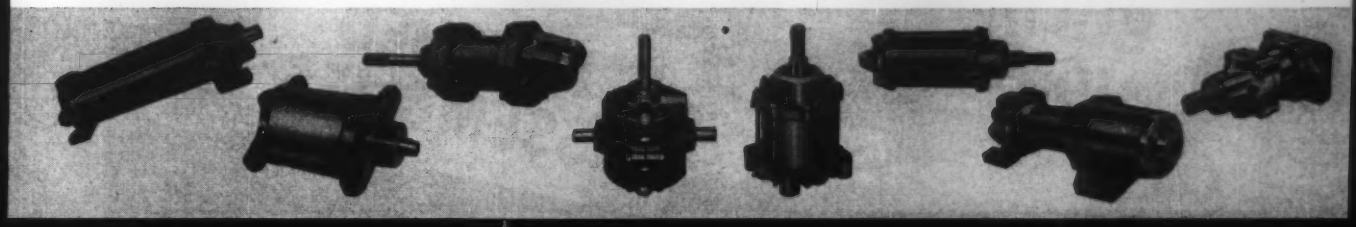
Experience proved in every major industry . . . ANKER-HOLTH

POWER CYLINDERS SAVE YOU TIME, TROUBLE AND MONEY

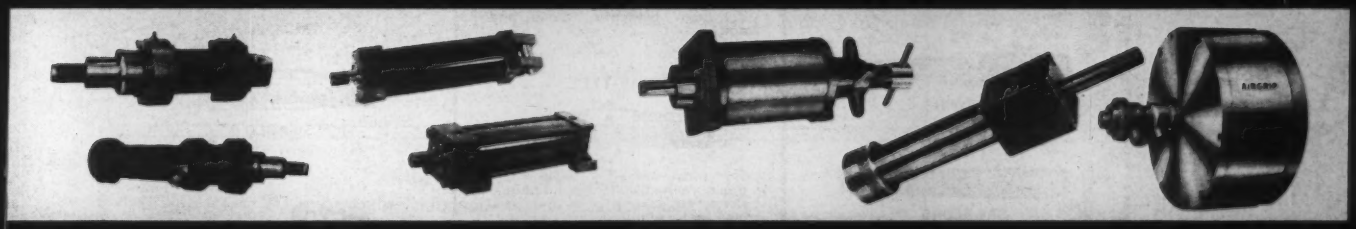


Select your needs

from the World's Widest Selection of Standard Cylinders



Check these compelling reasons why Anker-Holth air and hydraulic power cylinders save you time, trouble and money – widest selection of standard models | reliability through military accepted quality control program | simplified maintenance | all mountings available | bores 1" to 30" | strokes to 40' | built to JIC specifications | nationwide engineering service on call | complete facilities to engineer any power cylinder application outside the standard model.



Only a few models could be shown above

This free catalog shows them all

ANKER HOLTH

DIVISION, THE McDOWELL-WELLMAN COMPANIES

Circle 451 on Page 19

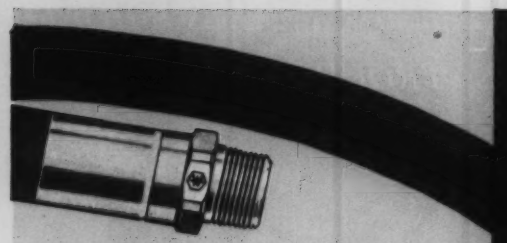
Send this B-2

ANKER-HOLTH DIVISION
THE WELLMAN ENGINEERING COMPANY
2723 CONNOR STREET, PORT HURON, MICH., U. S. A.

Name_____

Company_____

Address_____



Any Size
Any Length
Any Pressure
Any Quantity
Any Hose End Combinations

From the hose types and styles shown below

depend on **WEATHERHEAD** for SERVICE and SATISFACTION on all industrial hose applications

BULK HOSE

FINISHED ASSEMBLIES

STANDARD HOSES

LOW PRESSURE

H-9 — SAE 30R2

H-100 — COTTON COVERED

MEDIUM PRESSURE

H-17 — SAE 100R3

HIGH PRESSURE

H-25 — SAE 100R2

MEDIUM HIGH PRESSURE

H-69 — SAE 100R5

MEDIUM HIGH PRESSURE

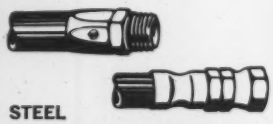
H-108 — SAE 100R1

HIGH PRESSURE

H-35 — Spiral Wire Reinforced

H-50 — Spiral Wire Reinforced

REUSABLE ENDS



STEEL

STANDARD 2-PC. END

For fast assembly and positive, leakproof connections. Designed for dependable performance under high pressure. Skive and no-skive.

CLAMP-TYPE

For most two-wire braid high-pressure hydraulic hose applications. No skiving of hose or special tools required.

BARB-TITE ENDS

Fast, easy push-on, stay-on hose ends for all types of low pressure applications. Sizes ¼" to ¾" I.D. Rugged and durable.

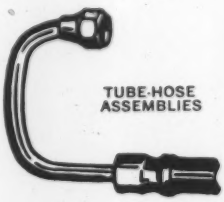
HOSE ASSEMBLIES

PERMANENTLY ATTACHED HOSE ENDS

Swaged or crimped permanently attached hose ends. Any quantity, any size, any type. ⅛" to 2". For all working pressures.

CRIMPED

SWAGED



TUBE-HOSE ASSEMBLIES

THE WEATHERHEAD COMPANY

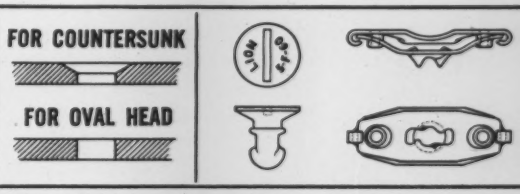
FORT WAYNE DIVISION • Dept. MD-12, 128 West Washington Blvd. Fort Wayne, Indiana

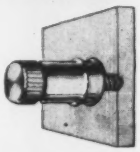
Captive Quick-Opening Fasteners:

Southco standards provide many benefits at low cost for access through doors, covers, panels and into drawers

LION ¼ TURN FASTENERS

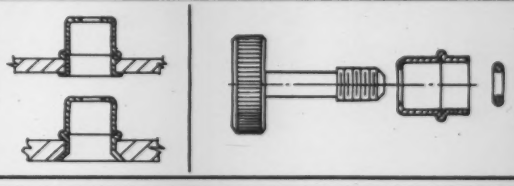
Quick, positive locking, by fractional turn. Tight seal formed by compression of leaf spring. Alignment and stack height not critical. Approved for aircraft use. Rugged. Extra strength provided by swaged nose. Vibration resistant.

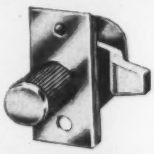




RETRACTABLE SCREW FASTENERS

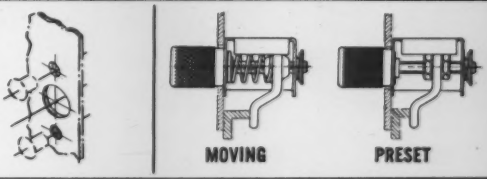
Stand-off thumb screws from stock to eliminate costly, special fasteners. Installed quickly without special tools. Accommodate misalignment. Complete range of standard sizes.

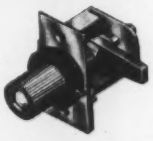




ADJUSTABLE PAWL FASTENERS

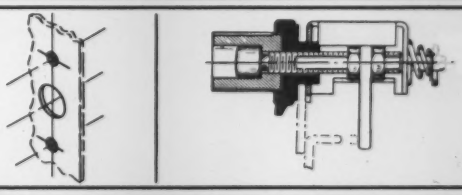
Pre-assembled, quickly installed. Accommodate variations in frame thickness up to ½ inch. One-quarter turn closes, additional turns increase grip pressure. Attractive appearance, long life. Moving or pre-set pawl. Miniature, intermediate and large sizes.





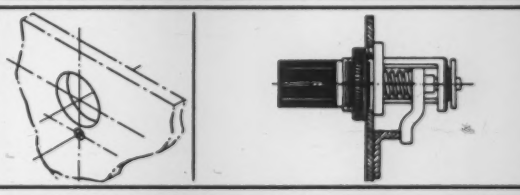
ADJUSTABLE PAWL FASTENER

Has twin-knob control. One knob controls pawl, pointer shows pawl position. Other knob controls amount of pressure to seal closure with uniform pre-set compression. Easily installed.



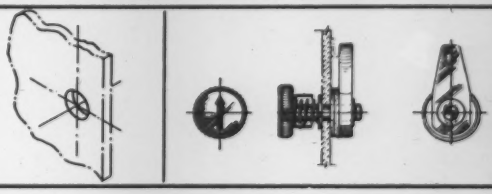
ADJUSTABLE PAWL FASTENER

Compact and rugged. Eliminates rivets or bolts to save installation time. Three types cover grip range up to ¾". Supplied either with integral metal and plastic knob, plastic knob or for your knob.



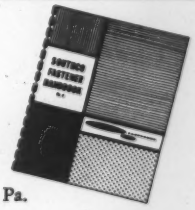
ARROWHEAD DOOR LATCH

Requires only one hole to install. Operates on quarter turn. Holds under spring tension. Arrow shows pawl position; no pawl stops required. Uses minimum inside space.



Free Fastener Handbook

Send for your complete Southco Fastener Handbook, just printed. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.



SOUTHCO FASTENERS

LION

© 1959

ANOTHER IN A SERIES
OF MOTOR FACTS
FROM ALL INDUSTRIES

Sand... heavy rain... extreme heat...

Nothing stops These Westinghouse Life-Line A Motors

dependably driving oil well pumps in Odessa, Texas district of The Atlantic Refining Company, 24 hours per day, 7 days a week!

"Here's an application," says A. P. Johnston, production engineer at The Atlantic Refining Company, "where we must have continuous motor operation . . . sometimes for as long as 18 months . . . with virtually no maintenance or repair. Many of our pumping stations are remotely located, automatic and unmanned. Any stoppage or motor failure would result in the loss of several hundred barrels of oil. Motor repairs in the field are prohibitive in cost. We must have *complete* motor reliability and that's exactly what we get from our Westinghouse Life-Line® "A" motors."

How about you? Got a really tough motor application which you can't afford to pamper? Then ask your Westinghouse sales engineer to show you how the dependable Life-Line "A" pays for itself through reduced maintenance and repair. Or write to Westinghouse Electric Corp., P.O. Box 868, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

J-22055-R

YOU CAN BE SURE... IF IT'S Westinghouse

On this pumping unit, the 15-hp Life-Line "A" motor operates in an atmosphere of damaging dust, sand and moisture. Despite continuous, heavy-duty service, motor has never suffered any overheating since first installed. Prelubricated bearings of the Life-Line "A" eliminate periodic greasing . . . keep lubricant in . . . dirt out.

Circle 454 on Page 19

Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
- Electrical or electronic drives, controls, systems
- Hydraulic or pneumatic systems, drives, controls
- Materials and finishes selection or specification
- Design for manufacture or production design

Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

Circle 455 on page 19→

QUESTION:

Can you cold head this drill chuck key?

ANSWER: *YES! with*

CENTRAL SCREW COMPANY *engineering and KEYSTONE XL WIRE*

Questions like this are asked every day at Central Screw Co., Chicago, Ill.—and this is a typical answer! For Central Screw depends on Keystone XL Wire to head more than 7,500 stock items by the millions—and for many of its 20,000 specials. Here, as with many other progressive fastener manufacturers across the country—"know-how" combines with Keystone XL Wire quality and flowability to produce a superior product at sharply reduced costs.

For example, by cold heading this drill chuck key, gear cutting was eliminated and machining was reduced. Overall costs were cut about 50%. This is one of *millions* of examples of how Central's "Fasteneering"® profitably puts Keystone XL Wire to use. You can do the same. Your Keystone representative will help you. Call him!

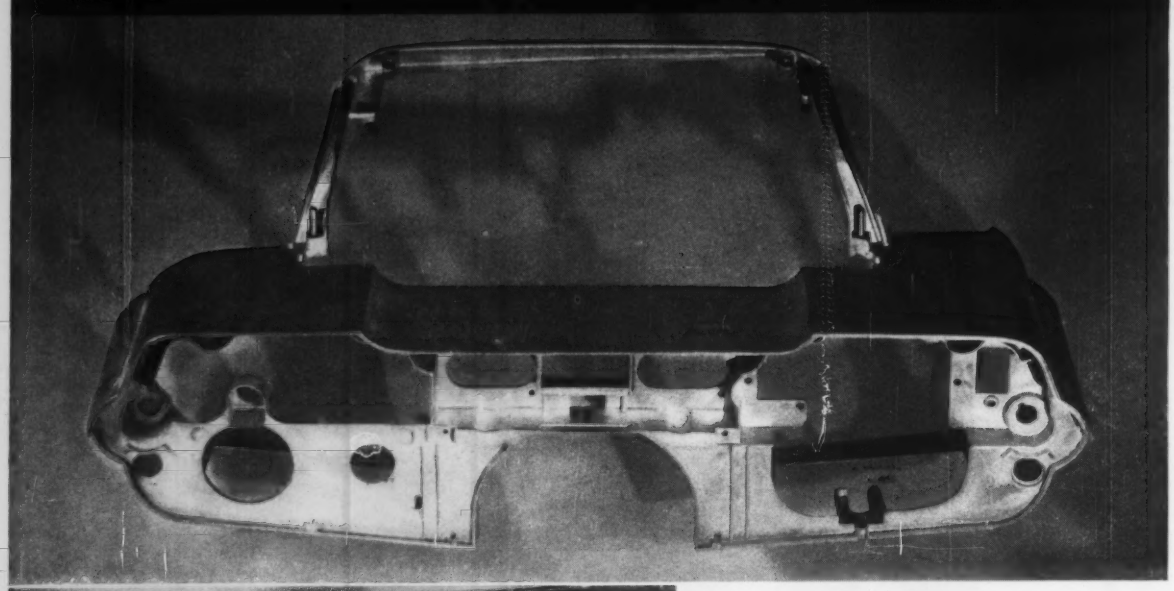
Keystone Steel & Wire Company, Peoria 7, Illinois

Five operations now produce this chuck key: heading on a 2 blow header, cut pointing, drilling, chamfering and heat treating.
ACTUAL SIZE
More Central Screw examples of Keystone XL Wire flowability are (above) this fastener with an 8 diameter thin shell head, and (right) fastener with 6½ diameters in the sharp, clean head and square shoulder.

KEYSTONE

WIRE FOR INDUSTRY

IT'S LIGHTER THAN YOU THINK!



...RIGID, RATTLE FREE and EASY TO ASSEMBLE WHEN DIE CAST with ZAMAK®

Light-weight, ZINC die cast instrument housings are finding extensive use in 1960's precision-engineered automobiles. Designed for the new MERCURY, this is an excellent example of the way automotive engineers are getting the most value—at low cost—from a single, rigid, rattle free and easy-to-assemble unit.

Integrated designing of panels and instrument clusters for ZINC die casting eliminates the cost of sub-assemblies and extra parts, unitizes instrumentation, provides space-saving facilities for wiring and saves weight. In this one complex, thin-wall, ready-to-use ZINC die casting are integrally cast bosses and studs for rapid assembly, framing members and supports for finish pieces.

Here, as in many other applications, rugged but extremely thin-wall sections—possible only with ZINC die castings—minimize weight and are stronger **in proportion to thickness** than heavier sections. Weighing only 7½ pounds, the over-all measurements of this MERCURY instrument cluster are 22½″ long, 12″ high and 6½″ deep, with a minimum wall thickness of .037″.

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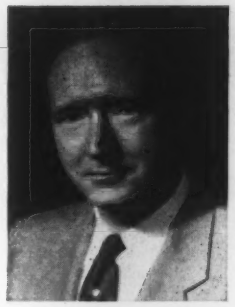


Shades of Charlie Wilson

THE sales meeting resembled a homecoming day pep rally. A succession of inspiring addresses by top people from management, research, manufacturing, advertising, etc., was supposed to have fired up the salesmen to fever pitch.

After such impressive demonstrations no one could doubt that theirs was the leading dog food company, producing the finest, most attractively packaged, dog food in the world. "Then why," shouted the general sales manager, "why can't you fellows sell more dog food?" Silence for a moment. Then a plaintive voice from the back of the room grumbled, "The stupid dogs don't like it."

For dog food, substitute any product designed for a market—industrial or consumer—and you have the story of many a business today. Too often an important ingredient is missing—competent market research.

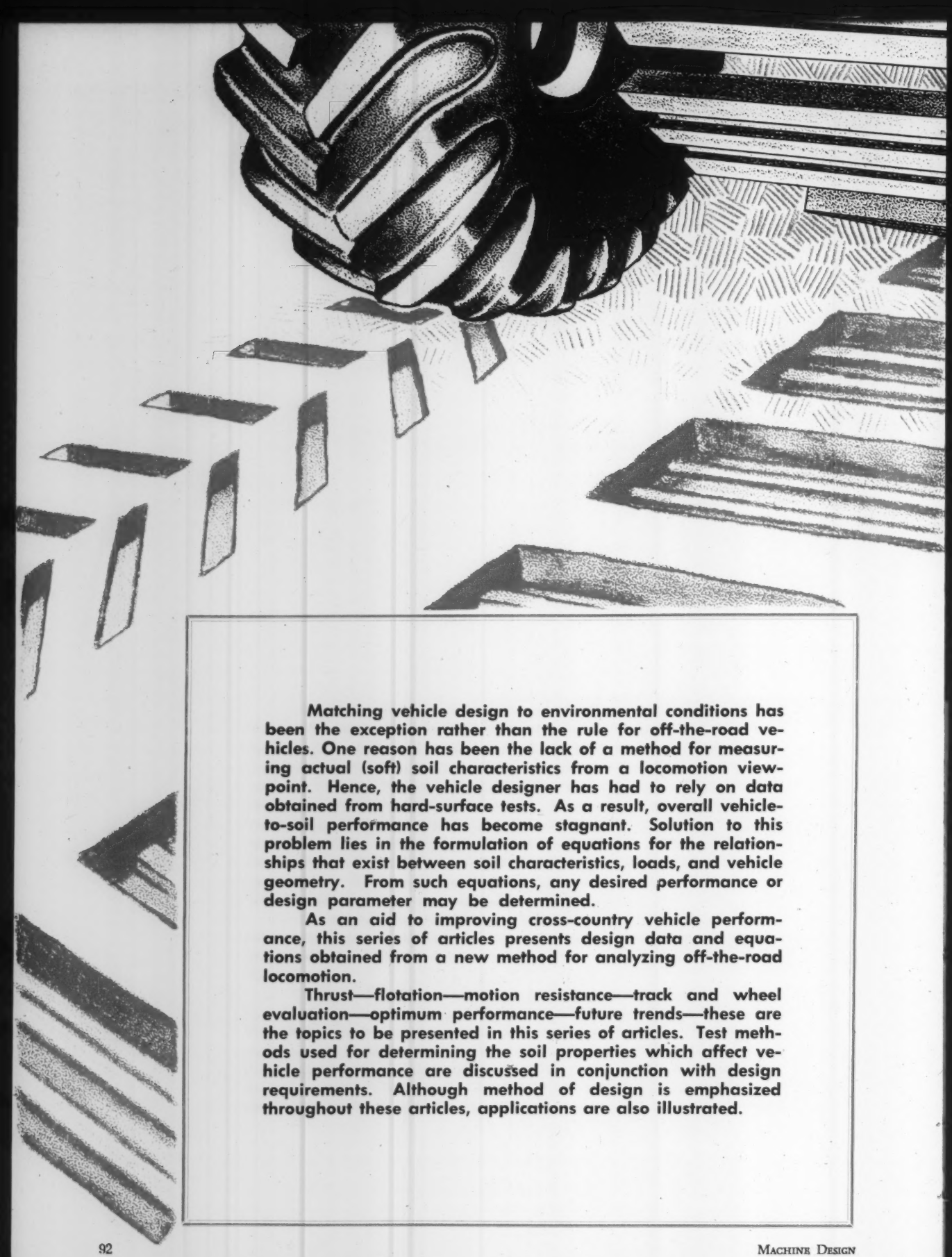
The engineer charged with the development and design of a new product is expected to avail himself of the latest findings of scientific and engineering research. He needs equally good support in the form of market information. He can't design in a vacuum.

But the engineer must also be willing to stand up against the half-baked notions of amateur market specialists. This type looks for superficial trends—maybe styling preferences. Perhaps the customer would rather have better engineering and operating performance.

Engineering management is entirely within its rights in questioning the professional competence of a consulting engineer. It should have the same privilege with respect to a marketing consultant—in-house or outside.

Responsibility of the design engineer is to develop, and design for manufacture, a product which can be sold in the market place. It pays to find out if the "stupid dogs" are going to like it.

Colin Carmichael
EDITOR



Matching vehicle design to environmental conditions has been the exception rather than the rule for off-the-road vehicles. One reason has been the lack of a method for measuring actual (soft) soil characteristics from a locomotion viewpoint. Hence, the vehicle designer has had to rely on data obtained from hard-surface tests. As a result, overall vehicle-to-soil performance has become stagnant. Solution to this problem lies in the formulation of equations for the relationships that exist between soil characteristics, loads, and vehicle geometry. From such equations, any desired performance or design parameter may be determined.

As an aid to improving cross-country vehicle performance, this series of articles presents design data and equations obtained from a new method for analyzing off-the-road locomotion.

Thrust—flotation—motion resistance—track and wheel evaluation—optimum performance—future trends—these are the topics to be presented in this series of articles. Test methods used for determining the soil properties which affect vehicle performance are discussed in conjunction with design requirements. Although method of design is emphasized throughout these articles, applications are also illustrated.

Mobility of Cross-Country Vehicles 1

Thrust *for propulsion*

M. G. BEKKER
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Detroit, Mich.

MATHEMATICAL models of soil-vehicle relationships are the backbone of a new approach to cross-country vehicle design. From a programmed evaluation of data obtained during model tests, any desired parameter of performance or design may be evaluated for various soils or soil conditions. From such an evaluation, the optimum vehicle weight, size, form, tire size, and load can be determined. This method embraces the newest concepts of "system-analysis," in which vehicle geometry and performance are evaluated for a complete spectrum of environmental soil conditions.

Hitherto, any radical departure from well-established trends required actual design, construction, and field testing of a new vehicle. However, time and cost involved in producing a large number of experimental models prohibited such tests. With this new method, however, a large number of vehicle concepts in many different soil conditions can be theoretically evaluated. Thus, the designer can analyze all conceivable choices and select the most rational optimum design.

This theoretical method is, so to speak, in a state of infancy, and considerable work remains to be done to increase the accuracy of predictions. However, results obtained have a definite value.

Rational adaptation of vehicle forms to the environment requires a knowledge of the physical relationships between soil and vehicle. For vehicle design, factors such as load, torque, speed, dimension, moment of inertia—including their definitions and determination—are well-established. However, soil values are not so well defined. Hence, any effort to match the vehicle to the soil on which it will operate must start with definition and measurement of terrain values pertinent to land locomotion. A survey of factors affecting off-the-road vehicle design begins in this article with a look at the nature of soil thrust and how it acts on vehicle tracks or wheels.

Fundamentals

Soil thrust is defined as the horizontal reaction produced by the ground when it is deformed by the load-carrying and propelling components of a vehicle—track or wheel. Theory and experiment indicate that thrust is generated by slippage of the vehicle.[1] Shear taking place under such circumstances is resisted by soil strength which provides the thrust necessary for propulsion. The shearing area extends along the ground contact area within the confines of the track or tire width, Fig. 1, and is caused by bond failure between the stationary

[1]References are tabulated at end of article.

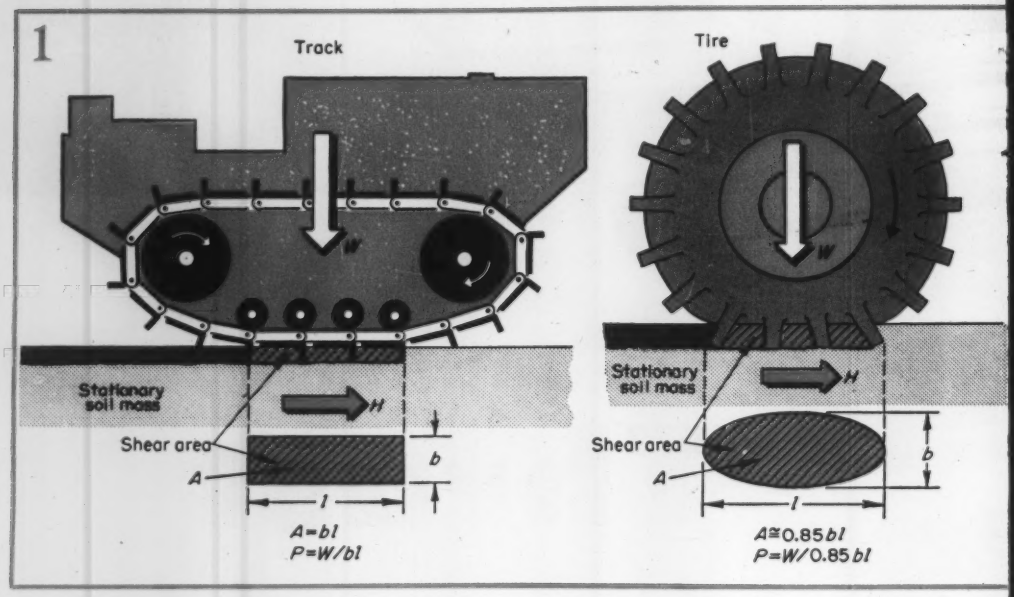


Fig. 1—Vehicle is propelled by reaction produced by soil when the area under the track or wheel is sheared.

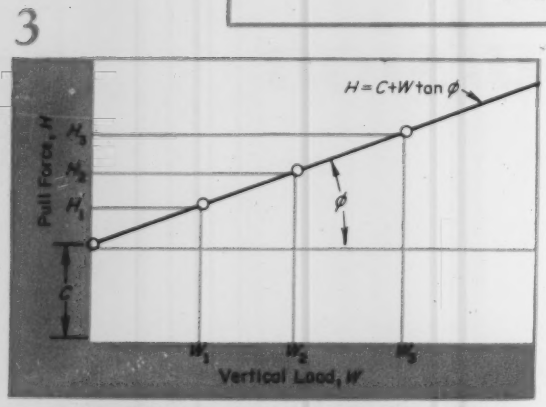


Fig. 3—Total cohesive force C and angle of friction ϕ for the soil are obtained by plotting maximum pull force H as a function of vertical load W.

Table 1—Soil Properties[1]

Type of Soil	Porosity (per cent)	Moisture Content (per cent)	Ground Pressure (psi)	Angle of Friction, ϕ	Coefficient of Cohesion c (psi)
From Germany		By Weight			
Loam with fine sand	58	14.2	2.9	——	——
			1.95	35°0′	0.014
			1	35°45′	0.356
	50.3	14.5	2.9	36°30′	0.3
			1.95	35°45′	0.342
			1	39°20′	0.6
	44.7	13.1	2.9	36°30′	——
			1.95	35°45′	2.14
			1	40°40′	1.93
Sand	40.6	4.7	2.9	32°15′	0.071
			1.95	34°40′	0.0085
			1.47	34°15′	0.2
			1	35°20′	0.328
	35.7	4.8	2.9	33°25′	0.56
			1.95	35°	0.427
			1	37°15′	0.455
From England		By Volume			
Clay		—		39°30′	2.8
Loam		39		35°	1.8
Sandy clay		34		30°30′	2.9
Clayey loam		27		27°	1.9
Sandy loam		29		25°	1.7
Peaty loam				20°50′	1.85
Sand		10.7		22°	1

soil mass and the soil trapped by or adhering to the cleats or tread.

This concept of soil shear is one of basic soil mechanics. The maximum force required to shear the soil along the ground-contact area, and hence the maximum soil thrust for one track or tire is

$$H_m = Ac + W \tan \phi \quad (1)$$

Since the uniform ground pressure of the vehicle is $p = W/A$, Equation 1 becomes

$$H_m = A(c + p \tan \phi) \quad (2)$$

Equations 1 and 2 are those mostly commonly used for thrust evaluation.[1,2,3]

To define the maximum propulsive power available in soil from Equations 1 and 2, the vehicle-dependent terms, A and W or p, and the soil-dependent values, c and ϕ must be determined. The vehicle values are usually given as part of the design data, but the soil values must usually be measured experimentally.

Nomenclature

A = Ground contact area, sq in.
b = Track or wheel width, in.
C = Total cohesive force, lb
c = Coefficient of soil cohesion, psi
H_m = Maximum soil thrust, lb
l = Contact length, in.
p = Uniform ground pressure, psi
$= W/A$
W = Weight carried by track or wheel, lb
ϕ = Angle of friction (between soil grains), deg

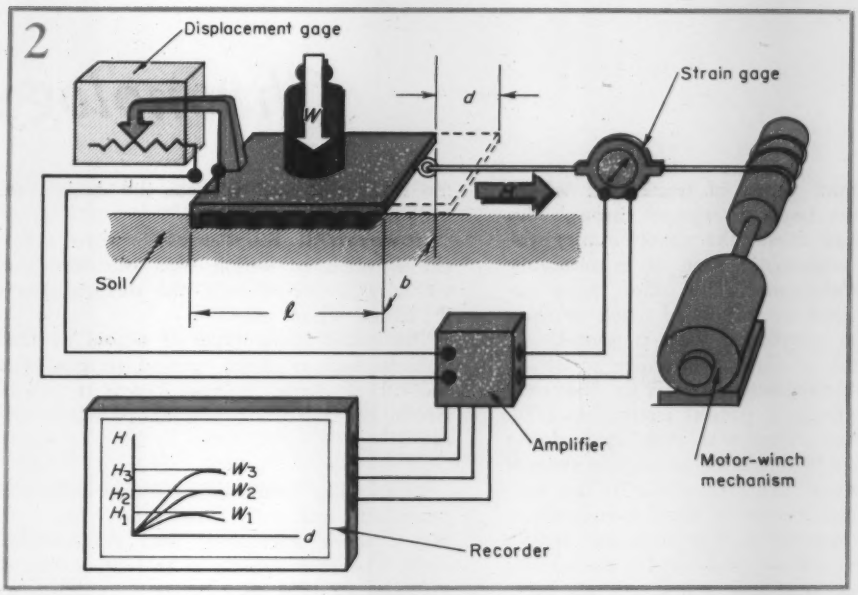


Fig. 2—Pull required to move a spudded plate with a load is measured to determine shear in soil.

Evaluation Techniques

Various techniques have been developed for measuring c and ϕ. Among these techniques is the "quick-shear test," which is adequate for soil-thrust evaluation.[1,2] For this test, a spudded plate with dimensions b by l, Fig. 2, is loaded with weight W and is moved distance d, by motor-winch mechanism. The instantaneous pull H, and corresponding shift d are plotted on x-y recorder, which registers the electric impulses of strain gage and displacement gage which are fed through amplifier.

If this operation is repeated in the same soil with at least three different loads, W_1, W_2, W_3, three curves will be obtained, Fig. 2. The maximum heights of these curves, H_1, H_2, H_3, are then plotted as a function of corresponding loads W_1, W_2, and W_3. The resulting curve is practically a straight line as shown in Fig. 3. The intercept of this line with the vertical axis represents the total cohesive force, $C = blc$. Hence, the coefficient of cohesion may be determined from

$$c = \frac{C}{bl} \qquad (3)$$

Angle of friction ϕ is read directly from the graph as the slope of the straight line. Hence, both soil values may be obtained by this procedure.

Theoretically, test-plate sizes and loads should have the same order of magnitude as those of real ground contact areas and loads. However, experience suggests that this is not necessary, and the measurements of c and ϕ taken with plate sizes of 25 to 40 sq in. and loads up to 3 or 4 psi are sufficient.

Since the soil of a test site is usually nonhomogeneous, each measurement should be repeated three to five times for a given W, and the results should be averaged.

Several instruments, based on the quick-shear test principle, have been developed. Use of a circular shear ring instead of a rectangular plate is one preferable modification. This configuration eliminates much of the bulldozing created by the front edge of the plate, particularly at higher loads. Hence, plate shrinkage is less.

A schematic drawing of a shear-ring instrument used by the Land Locomotion Laboratory of the Ordnance Tank-Automotive Command is shown in Fig. 4. A rod is loaded with weight W and rotated by a motor. The torquemeter records the shearing force on a ring, and the slip ring denotes angular position α of the shear ring. The electric impulses are recorded on the chart of a recording set. Theoretical details of measuring soil strength with a shear ring have been extensively considered by ASTM.[4]

Soil Values

Frictional values for ϕ obtained from tests range from 0 to 40 deg. Normally, these values do not depend on moisture content. However, cohesion does change with moisture content. This change may be very small, or may reach values of a few pounds per square inch for heavy wet clay.

Generally, c varies from 0 in dry sand to 3 psi in plastic saturated clay, while ϕ varies from 0 in plastic saturated clay to an average of 35 deg in dry sand. Table 1 indicates the variations which can

Chronology

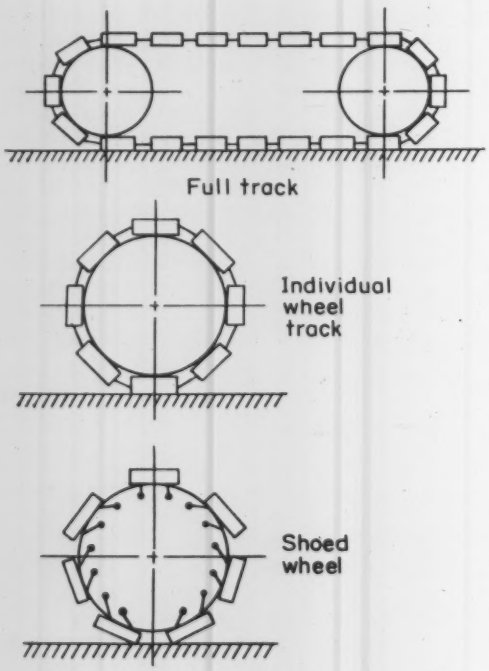
Four distinct types of track and wheel vehicles have been developed through the years. One of these, the cross-country vehicle with pneumatic tires, is a relatively modern development. The other three vehicle-types had some sort of track or shoe arrangement combined with a wheel.

One of the earliest references to cross-country vehicles is contained in the context of an English patent issued in 1770: "the invention consists in making portable railways to wheel carriages so that several pieces of wood are connected to the carriage which it moves in regular succession in such a manner that a sufficient length of railing is constantly at rest for the wheels to roll upon, and that when wheels have nearly approached the extremity of this part of the railway, their motions shall lay down a fresh length of rail in front . . ."

Although the patent description is rather vague, the idea embraces one of the two basic track and wheel designs. If the "tracks" formed an endless chain around the front and rear wheels, the design was truly a full-track vehicle.

However, if the "tracks" were simply shoes, each of which was attached individually to the wheels, the design was of the shoed-wheel type.

The other basic type of wheel or track vehicle had a chain girded around each individual wheel. Hence, it was a link between the full-track and shoed-wheel concepts.



During the 1800's many ideas were compounded, but only the shoed-wheel vehicles were successful and commercially used. The first vehicle of this type was developed in 1864 and for two decades was the only commercial cross-country vehicle.

This era also saw the advent of the mechanical propulsion system—first steam and then the internal-combustion engine. With these developments came changes in the steering mechanisms. In one of these arrangements, the simplest for self-propelled vehicles, a driving track was used in the rear of the vehicle and the front wheels were pivoted around a vertical center for steering.

Use of the shoed-wheel vehicle on rough terrain evidently posed problems, because in 1899 a spring-suspension system was introduced in one shoed-wheel design. Also during this period, the first reference to soil deformation as a design criterion is found.

During the early 1900's, development of cross-country vehicles took a back seat to the automobile. Efforts were even made to attach tracks to the pneumatic tires to modify the auto for off-the-road operation. However, the heavy duty required was more than these early highway vehicles could take.

The concept of full-track vehicles gained in popularity at the turn of the 20th century. As shoed-wheel designs reached their upper limits, the full track idea was the only avenue to advancement. During this era, the problems of snow and soil mechanics were first linked to vehicle mobility.

Most of the mechanical innovations for full-track vehicles developed during this period were concerned with the steering mechanisms. Two of the more important

of Crawlers

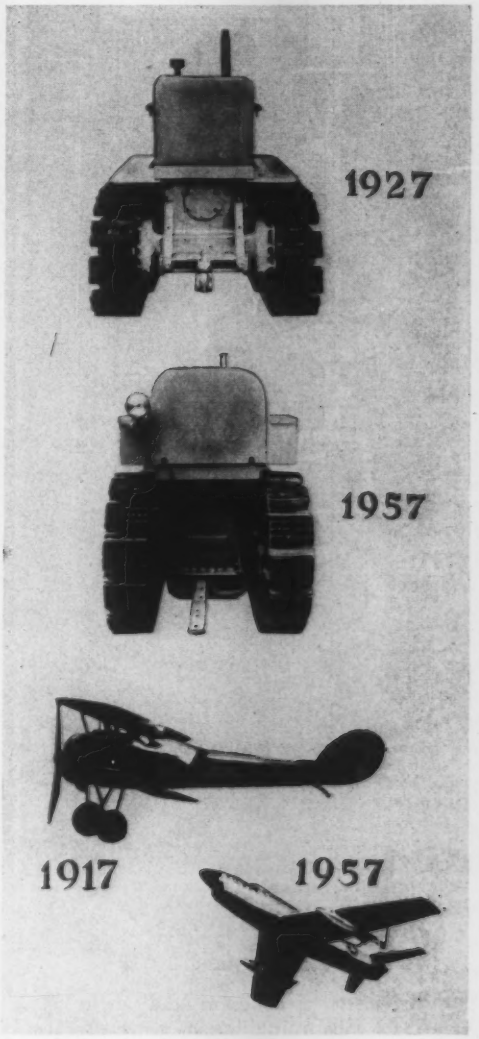
designs were: Adaptation of the automobile differential with dog clutches attached to the power shafts, and development of the hinged vehicle. In this latter design, the vehicle body was divided in two parts and hinged about a vertical axis. Steering was accomplished by turning each part of the vehicle around the pivot.

In 1911, a track vehicle was developed which became the predecessor of all modern farm tractors. Since this initial design, changes in track types, mechanism locations, and general layout have been slight.

World War I brought some efforts to satisfy the principles of soil loading. Uniform distribution of loads over the entire contact surface of the track was initiated by using a large-pitch track carried by several bogies. However, although many new areas for investigating vehicle-to-environment relations were opened during the war, the demands of modifying existing mechanisms to new applications left little time for basic vehicle studies.

The period between the two World Wars saw organized development programs set up for fundamental study of track and wheel vehicles. Definitions of merit for various soil-vehicle relationships were obtained through farm-tractor testing. From these findings, many principles of land locomotion were derived.

Controlled differential steering and the Diesel engine were developed during this era. However, these features were applied as modifications to the basic 1911-type tractor. Also introduced at this time was the wheeled tractor with steel-rimmed grousers. These wheels were later changed to large pneumatic tires.



Early in World War II, the development of higher-speed engines, electric drives, planetary-gear steering mechanisms, rubber-rimmed bogies, and better suspension systems also improved the performance of existing track vehicles. However, all design concepts up to this time were based on a philosophy of increasing tractor size to gain greater load capacity.

When vehicle weights and dimensions reached their upper limits, the various unknown factors affecting vehicle performance had to be considered. Elaborate test setups and prototype models were built. These methods were costly. Only recently have efforts been made to evaluate soil-to-vehicle relationships on a less expensive method.

Historically, cross-country vehicles appear to have come a long way. But when compared to the rapid advances in aircraft design, progress in off-the-road equipment development seems slight.

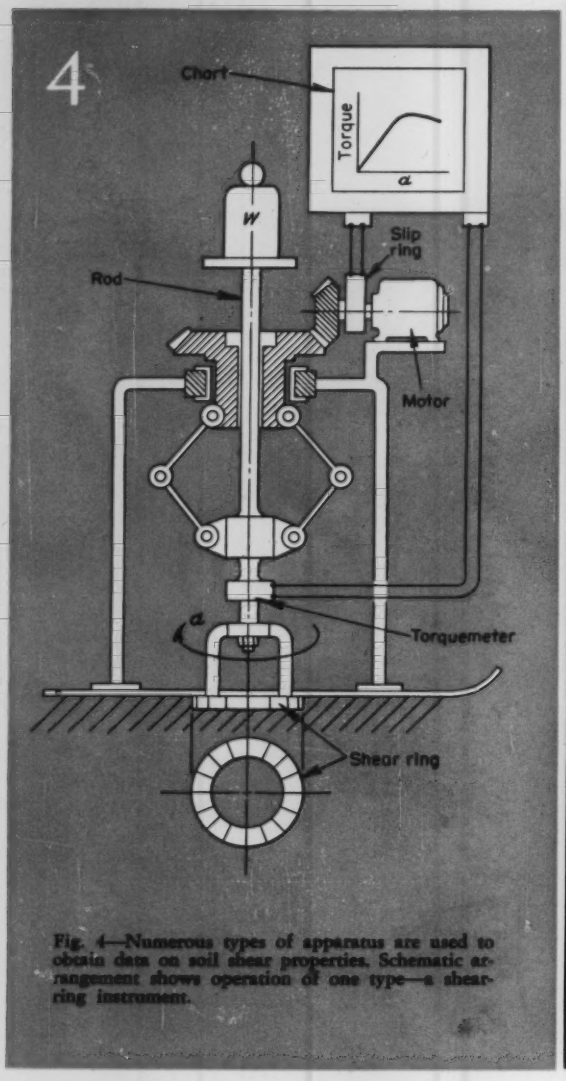
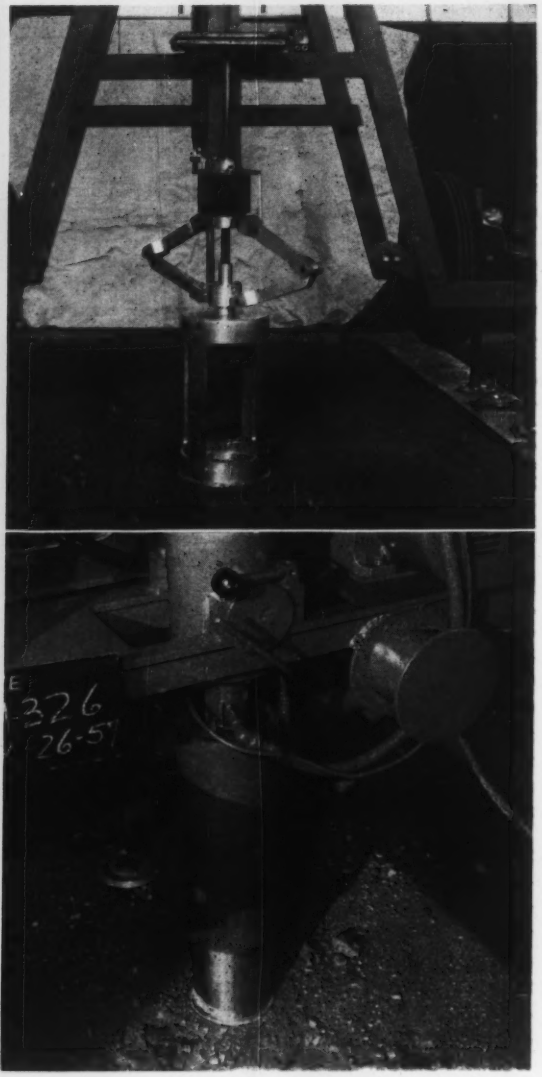


Fig. 4—Numerous types of apparatus are used to obtain data on soil shear properties. Schematic arrangement shows operation of one type—a shear-ring instrument.



Photo, courtesy Caterpillar Tractor Co.

exist in the coefficient of cohesion and angle of friction obtained for soils from different geographical areas.[3] The following example gives the procedure for determining soil thrust and its relationship to vehicle weight and contact area.

Example: Assume that the vehicle is to operate in dry sand, $c = 0$ and $\phi = 35$ deg, and in wet heavy clay, $c = 1.5$ and $\phi = 0$ deg. From Equation 1, the thrust produced by the dry sand is $H_m = W \tan 35 \text{ deg} = 0.7W$, and the thrust produced by the wet clay is $H_m = 1.5A$.

Hence in dry sand, soil thrust depends on W only. The heavier the tractor, the more thrust it develops. In a plastic frictionless clay, however, the thrust is independent of vehicle weight, and depends on ground contact area A. Thus the larger the tracks or wheels, the more thrust produced. Accordingly, to increase thrust in frictional soils, tractor weight must be increased. In plastic frictionless soils, the size of the ground contact area should be increased.[5]

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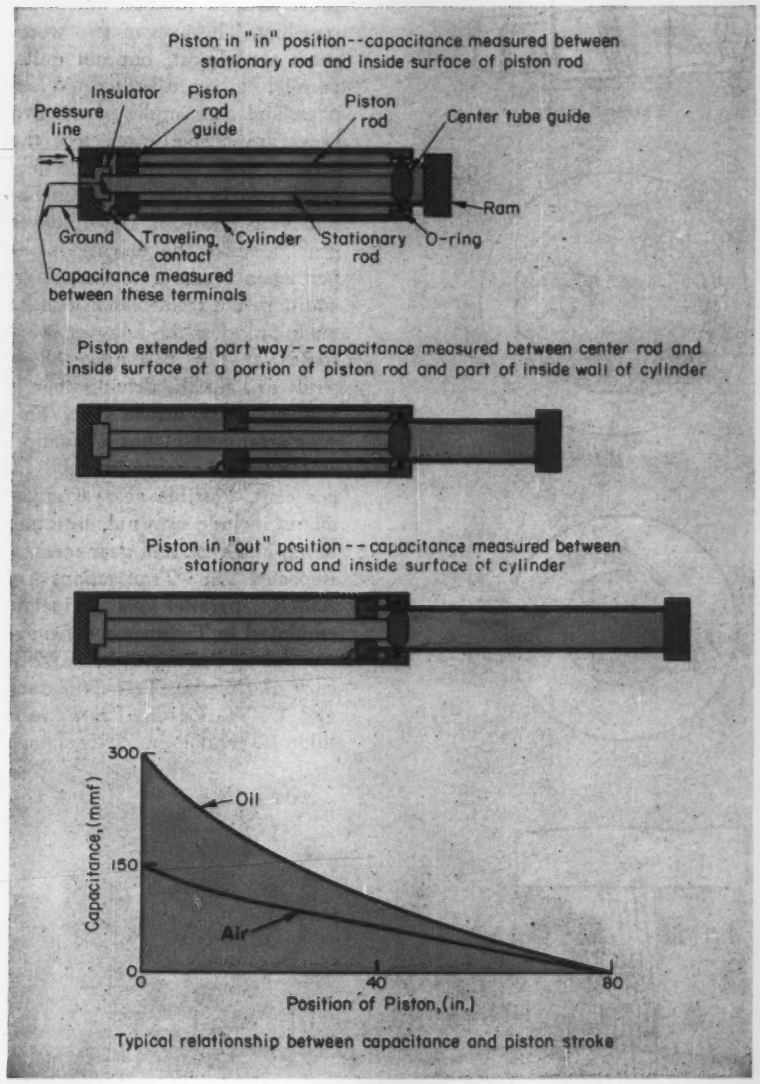
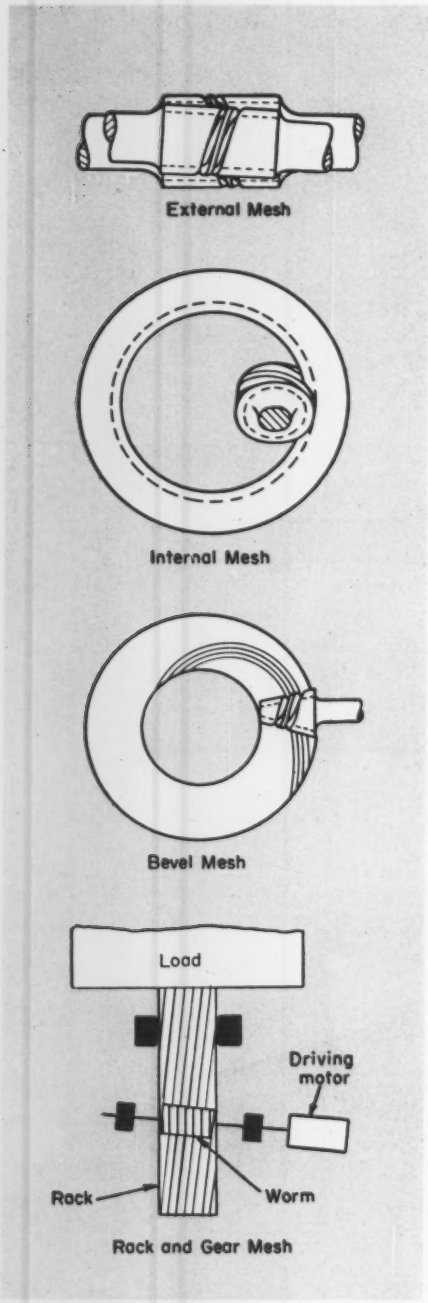
scanning the field for *ideas*

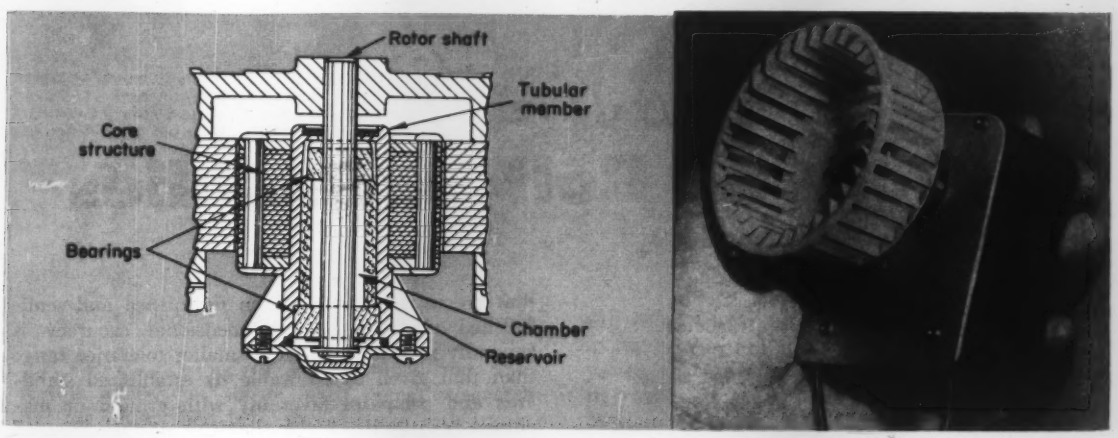


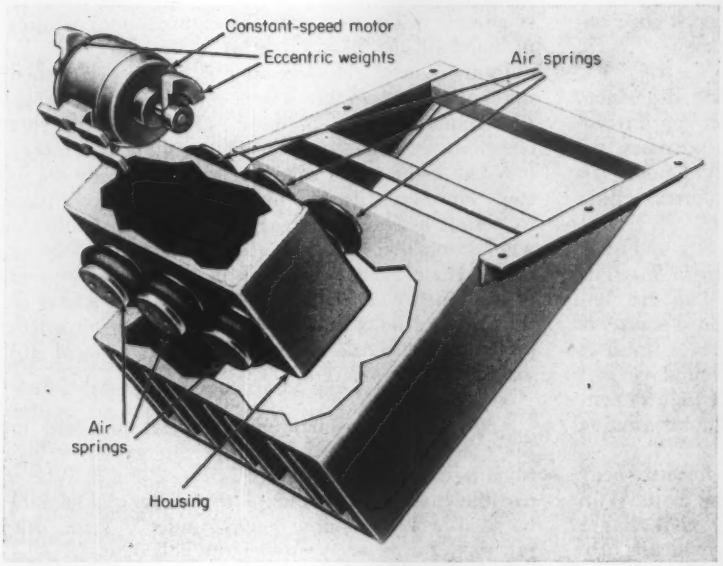
Built-in "transducer" circuit simplifies measurement of piston travel in long - stroke cylinder. A central metal rod is supported by an insulating bushing in the end of the cylinder. A hollow piston rod is kept in alignment with the central rod and cylinder by an insulating guide ring. Electrical circuit is maintained between the piston rod and cylinder by spring contact. The cylinder is grounded and a shielded electrical lead connects the central rod to a remotely-located instrument which indicates piston-rod position. When piston is fully extended, the capacitance between the central rod and inside surface of the cylinder wall is measured. In any intermediate position, the capacitance measured is between the values measured at the extreme positions and is a function of the piston-rod position. The relationship between capacitance and piston position depends upon the size and spacing of the three main elements and the fluid used as a dielectric. Measuring principle developed by W. E. Cawley and C. E. Frantz, Hanford Atomic Products Operation of General Electric Co., Richland, Washington.



"Parallel-axes" arrangement of worm-gear pairs increases operating efficiency and prevents load reversal and overspeeding. The axes of two worm gears are almost, but not quite, parallel to each other. When pitch and axes angles of the two gears are properly selected, the driving gear can drive the follower gear in either direction but will not rotate if the follower gear becomes the driving member when loads are reversed. In addition, the transmission can be made to lock if the follower overspeeds; that is, if a force which tends to help the driving gear is applied to the driven gear. This gear arrangement has a practical efficiency of approximately 90 per cent. Possible gear arrangements include external, internal, bevel, and rack and gear meshes. Reported in *Transactions of ASME*, parallel-axes principle employed in Twinworm drive developed by B. Popper, Israel Ministry of Defense, TelAviv, Israel, and D. W. Pessen, Israel Institute of Technology, Haifa, Israel.

Trapped oil provides permanent lubrication for rotor-shaft bearings. A tubular member has semi-porous bearings fixed within its bore. The bearings are separated to provide a chamber for lubricating oil. This chamber surrounds the rotor shaft that extends through the bearings and has a tubular liner of oil-absorbing material. The absorbent material is separated from the shaft to permit free shaft rotation and contacts the bearings which absorb the oil. Permanent-lubrication principle employed in electric motor developed by Howard Industries Inc., Racine, Wis.





Stepless amplitude adjustment is provided in a vibration generator by two banks of air springs. The springs act as a flexible source of energy input since their stiffness can be changed. In operation, a constant-speed motor rotates a set of small offset weights. The weights generate a concentrated centrifugal force against the springs. At natural frequency, the springs amplify the input forces. Control principle employed in a vibrating feeder developed by Carrier Conveyor Corp., Louisville, Ky.

Fig. 1—Four types of commercially available bolts showing (left to right) regular unfinished machine bolt; cold-formed body cap screw or finished hexagon bolt; special machined-body bolt; and regular semifinished machine bolt

How to simplify design of

Close-Fit Bolt Assemblies

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Engineer In Charge of Standards
ALCO Products Inc.
Schenectady, N. Y.

DESIGN of bolted assemblies often requires specification of a close fit between bolts and holes to meet special joint requirements. For such assemblies, necessary accuracy of fit can usually be obtained to cost advantage by the combination of certain standard bolts and holes reamed to suit bolt-body diameters. Factors that influence good design practice are outlined in this article.

Dimensional Relationships: In this discussion, "finished hexagon bolts" and "hexagon cap screws" are considered as identical. For design purposes, the difference is only one of terminology among the various bolt and cap screw manufacturers within the range of $\frac{1}{4}$ through $1\frac{1}{2}$ in.

Consider the four types of bolts shown in Fig. 1. The unfinished and semifinished hexagon machine bolts offer greater cost advantages but are impractical for close-tolerance application because of possible dimensional variations and surface finish of the bodies. Conversely, the special ground or machined-body bolt has the advantage of high dimensional accuracy but is the poorest choice from a cost standpoint.

Practical compromise is the cold-formed body hexagon cap screw or finished hexagon bolt. With present methods of manufacture, the body has a smooth, accurate cylindrical form without the ribs that are usually produced on unfinished and semifinished machine bolts. Dimensional accuracy is generally maintained over a smaller tolerance range than that given as allowable by established standards and compares favorably with ground or machined-body bolts. Major diameter of the threaded end is kept slightly below the body diameter, enabling the end to enter a hole reamed to fit the body.

Of course, this class of bolt is not suggested for use where accurate, full bearing must be obtained, such as in camshaft-section joints. Here, the bolt is ground to a fine tolerance and the hole is accurately reamed so that the combination requires no hand fitting.

In the use of cold-formed cap screws or finished hex bolts, one possible source of dimensional variation should be kept in mind. On statistically rare occasions, excessive spin-up while rolling the thread may cause the major diameter to exceed body diameter. However, the cost of correcting this condition to permit assembly in reamed holes is insignificant when compared with the savings made possible by use of these fasteners instead of the special ground or machined-body bolts. When desired, cap screws or finished hex bolts may be carburized and hardened, preferably with the threads protected to avoid absorbing the extra carbon.

Application Considerations: Typical practices in the use of cold-formed body hex cap screws or finished hex bolts are illustrated in Fig. 2 and 3. Where possible, bolts with standard thread lengths should be used. For a nominal length under $6\frac{1}{4}$ in., this full thread dimension is twice the bolt diameter plus

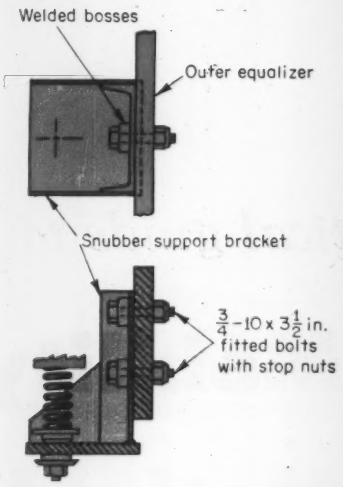


Fig. 2—Locomotive equalizer snubber assembly. Two cold-formed body cap screws or finished hex bolts with standard thread lengths are used as fitted bolts to prevent any movement of the snubber support bracket relative to the equalizer.

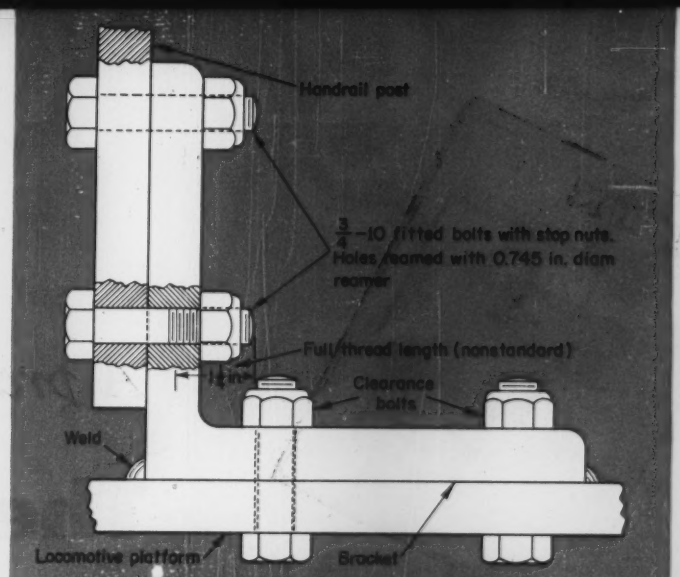


Fig. 3—Handrail-post assembly for diesel-electric locomotive. Handrail post is fastened to bracket by two cold-formed body cap screws used as fitted bolts. Thread length is shorter than standard to provide full bearing of bolt body at shear joint between post and bracket. Bracket is held on top plate of locomotive chassis by two cap screws in clearance holes and is welded to top plate in assembly to take shear loads produced when cars are coupled to locomotive. In practice, the holes for the fitted bolts are drilled about 0.015 in. smaller than the reamer which has a diameter 0.005 in. under nominal bolt size. Reaming usually provides a hole slightly larger than the reamer. In assembly, bolts are hammered home and stop nuts are tightened. Ramp between bolt threads and body aids driving and tightening operation; no lubricant is used beyond oiliness of bolts as received.

1/4 in. With longer bolts, the addition is 1/2 instead of 1/4 inch.

However, this length may provide too much thread where a shear joint comes near the nut as can happen in a shackle or a fork-and-eye assembly. In such applications, care must be taken to insure that the ramp between full-body diameter and the nearest thread mark leaves sufficient bearing of the full body of the bolt in the hole at the near side of the fork. This ramp is produced while forming the bolt body down to about pitch diameter, ready for rolling the threads. The top of the ramp is about 1 1/2 to 2 1/2 pitches away from the first full thread.

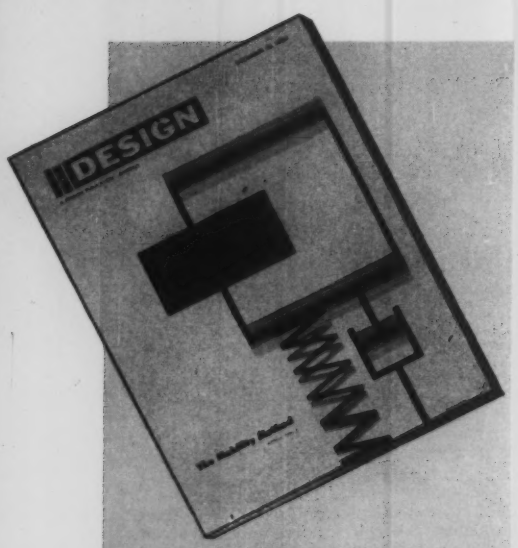
In close quarters, the amount of minus tolerance of the bolt length must also be considered because thread length is measured from the end of the bolt. If possible, at least three full threads should remain clear from the underside of the nut, although in cramped quarters this clearance may have to be cut to one thread. Nut hole countersink will add a little more free thread. Occasionally, it is necessary to use a plain washer or a lockwasher under the nut to gain more thread leeway. Increasing the number of free threads under the nut reduces stress concentrations at the threads. Sometimes, cold upset-and-extruded cap screws may be needed with threads longer than standard. All commercial bolts have a small fillet under the head, so holes for fitted bolts should be countersunk to accommodate this feature and to allow the head to seat.

In the assembly of bevel gears, one manufacturer uses special fitted-body cap screws to fasten the toothed gear rims to the flanged hubs and to absorb shear loads. To provide freedom for the bolt to fit the rim hole and the countersink in the hub flange, the threads are required to be a rather loose fit in the flange. This requirement is nicely covered by standard Class 2A threads now supplied as standard on all screws except the socket head variety. Class 2A threads may be used with Classes 2B and 3B internal threads, or in the older Classes 2 and 3 American Standard tapped holes.

The finished hexagon bolts and hexagon cap screws considered here are standardized in two common material specifications: SAE Grade 2 or low-carbon (AISI 1018) unheat-treated types and SAE Grade 5 (usually 0.38 carbon steel, heat-treated). The latter types are distinguished by a thin oxidized surface and three radial dashes on the top of the head. They are often designated as high-strength bolts or cap screws.

ASTM A325 also covers the heat-treated bolts but, for the service discussed here, bolts with cold-formed bodies should be specified. Diameters of these bolts now run from 1/2 through 1 1/4 in. and may soon reach 1 1/2 in. diameter. The cold-forming process limits body lengths to about 8 in. for sizes 1 in. and smaller, and to about 10 in. for sizes over 1 in. Coarse threads are the most common but fine threads are available.

Use of these general-purpose fasteners for the rather special services considered here can provide a significant cost advantage. This advantage applies even when thread lengths need to be special, since common practice is to adapt blanks of standard bolts. Where quantities are small, the cost advantages are even greater per piece.



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A practical guide to

The Mobility Method

Part 2—Mechanical-Network Analysis

Nomenclature

e = Natural logarithm base
F, f = Force, lb
$f_{blocked}$ = Force produced through an immovable object by an ideal force exciter, lb
g = Acceleration of gravity, in. per sec per sec
j = Imaginary operator
J = Inertia, in.-lb-sec^2
k = Translational spring gradient or rate, lb per in.
k_r = Rotational spring gradient or rate, in.-lb per rad
M = Mobility
m = Mass, lb-sec^2 per in.
r = Translational viscous responsiveness, in. per lb-sec
r_r = Rotational viscous responsiveness, rad per in-lb-sec
T_f = Force transmissibility
T_v = Velocity transmissibility
t = Time, sec
V, v = Velocity, in. per sec
v_{free} = Velocity produced across the terminals of an ideal velocity exciter when it is not connected, in. per sec
ω = Angular frequency, rad per sec
ω_n = Natural frequency, rad per sec

IN PRACTICE, mechanical systems usually consist of a number of basic elements connected together in a complex arrangement. Mathematically, the individual elements can be defined quite precisely. For the mobility method of analysis, these definitions and other fundamental concepts have been presented in a previous article (December 10, 1959 issue). This article will show how these concepts are applied to the dynamic analysis of complete mechanical systems.

Basic Relationships: To develop this approach, certain terms must first be clarified. A mechanical network is defined here as an entire aggregation of mechanical elements which are interconnected to form a mechanical device. Consider the typical generalized network diagram shown in Fig. 7, where the elements of the network are represented simply by lines. Each line, such as *AB*, *BC*, *CD*, etc., represents a branch. A connection of two or more branches forms a *junction* or *node*. Closed paths in the network, such as *ABCDEA*, are loops.

Usually, each branch of a network can be expressed mathematically as a mobility which may

. . . a powerful tool for analyzing the dynamics of mechanical systems

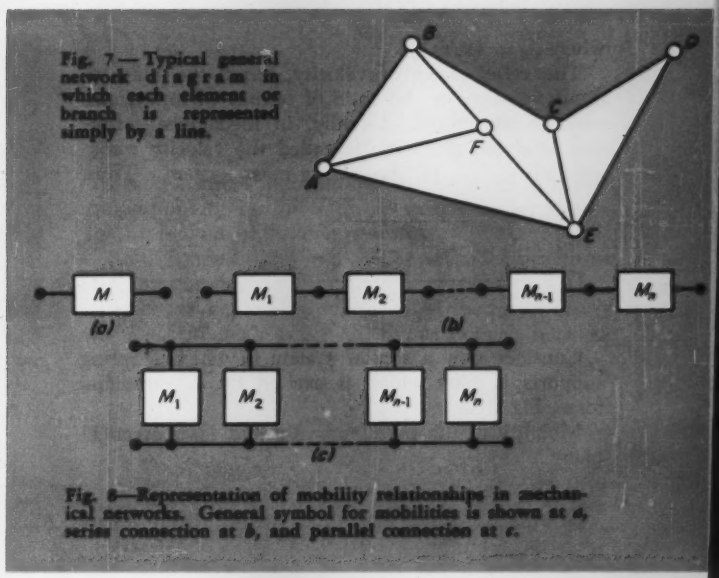


Fig. 7 — Typical general network diagram in which each element or branch is represented simply by a line.

Fig. 8—Representation of mobility relationships in mechanical networks. General symbol for mobilities is shown at *a*, series connection at *b*, and parallel connection at *c*.

have a real and an imaginary part. Since mobility depends only on the physical properties of an element, a branch may consist of a combination of either a mass or a spring, and some damping. These properties are considered to be in series and are directly additive.

The general mobility will be made up of a real part, called responsiveness r, and an imaginary part, excitability X, as proposed by R. Plunkett of the General Electric Co. Mathematically, this mobility can be expressed as $r \pm jX$. Schematically, a general mobility will be represented as shown in Fig. 8*a*.

Branches of mobilities are connected in series when their terminals are connected end to end with not more than two terminals at any junction or nodal point, Fig. 8*b*. In a series connection, the same force acts through all the elements in the series while the velocity across the combination is the sum of the velocities across the individual elements. Hence, total mobility M_t of a series connection is the sum of the mobilities of the individual elements:

$$M_t = M_1 + M_2 + \ldots + M_{n-1} + M_n \qquad (6)$$

Branch mobilities are connected in parallel when their terminals are connected to two common junction points, Fig. 8*c*. The same velocity must exist across all of the elements and the total force through the combination of elements is the sum of the forces through the individual elements. The total mobility of a parallel combination of elements is

$$\frac{1}{M_t} = \frac{1}{M_1} + \frac{1}{M_2} + \ldots + \frac{1}{M_{n-1}} + \frac{1}{M_n} \qquad (7)$$

or simply the reciprocal of the sum of the reciprocals of the mobilities of the individual elements.

Consider a series combination of a mass and spring excited by a velocity source, Fig. 9*a*. Assume that the velocity across the mass is required.

Total mobility of the series spring and mass is (See Table 4 of previous article):

$$M_t = \frac{j\omega}{k} - \frac{j}{\omega m} = j\left(\frac{\omega}{k} - \frac{1}{\omega m}\right) \qquad (8)$$

A typical frequency plot of mobility for this system on the complex plane is shown in Fig. 9*b*. From the definition of mobility, $M = v/f$, the force through the system is

$$f = \frac{v}{M_t} = \frac{v}{j\left(\frac{\omega}{k} - \frac{1}{\omega m}\right)} \qquad (9)$$

Velocity drop v_m across the mass is:

$$v_m = fM_m = \frac{v}{j\left(\frac{\omega}{k} - \frac{1}{\omega m}\right)}\left(\frac{-j}{\omega m}\right)$$

$$= \frac{-v}{\left(\frac{\omega}{\omega_n}\right)^2 - 1} \qquad (10)$$

where $\omega_n = (k/m)^{1/2}$

The relationship of velocity across the mass to input velocity, or the ratio of output to input, also may be significant. Usually, in mechanical-vibration analysis, this ratio is called the velocity transmissibility, T_v, of the spring-mass system. Thus,

$$T_v = \frac{v_m}{v} = \frac{\frac{v}{1 - \left(\frac{\omega}{\omega_n}\right)^2}}{v} = \frac{1}{1 - \left(\frac{\omega}{\omega_n}\right)^2} \qquad (11)$$

Consider now a similar system in which a spring supports a mass which is excited by a sinusoidal force, Fig. 10*a*.

Mobility of the parallel spring and mass arrangement is

$$M_t = \frac{1}{\frac{1}{\frac{-j}{\omega m}} + \frac{1}{\frac{j\omega}{k}}} = \frac{\frac{-j\omega}{k}}{\left(\frac{\omega}{\omega_n}\right)^2 - 1} \qquad (12)$$

A typical frequency plot of this mobility expression appears in Fig. 10*b*. Velocity drop across the spring is

$$v_s = v = fM_t = f\frac{\frac{j\omega}{k}}{1 - \left(\frac{\omega}{\omega_n}\right)^2} \qquad (13)$$

and force through the spring is

$$f_s = \frac{v_s}{M_s} = \frac{\frac{fj\omega}{k}}{\frac{1 - \left(\frac{\omega}{\omega_n}\right)^2}{\frac{j\omega}{k}}} = \frac{f}{1 - \left(\frac{\omega}{\omega_n}\right)^2} \qquad (14)$$

where M_s is the mobility of the spring.

Force transmissibility T_f of the spring-mass system is defined by $T_f = f_s/f$. Hence,

$$T_f = \frac{\frac{f}{1 - \left(\frac{\omega}{\omega_n}\right)^2}}{f} = -\left[\frac{1}{1 - \left(\frac{\omega}{\omega_n}\right)^2}\right] \qquad (15)$$

The negative sign before the expression for force transmissibility is necessary to satisfy the condition, $\Sigma F = 0$, at the junction of the spring and the mass (see vector diagram for first example in *Typical Network Calculations*). Expression for transmissibility is developed from arbitrary assignment of directions of forces and signs of velocities in circuit. Actual direction of force must be determined from vector diagram and assumed directions changed if necessary.

Since T_v for the previous system (Equation 11), Fig. 9, is equal to T_f of this system, Fig. 10, transmissibility of system response versus frequency may

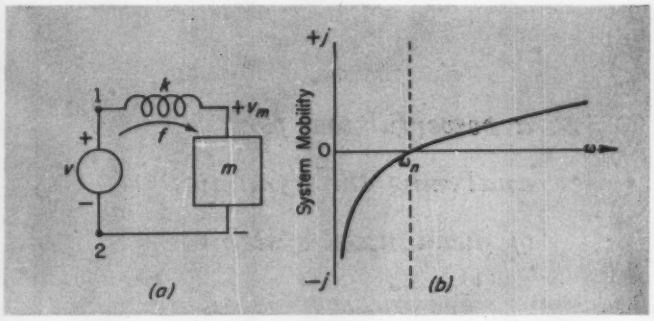


Fig. 9—Velocity-excited system with a mass and a spring in series. Circuit diagram is shown at *a*, frequency plot of mobility across points 1 and 2 of circuit at *b*.

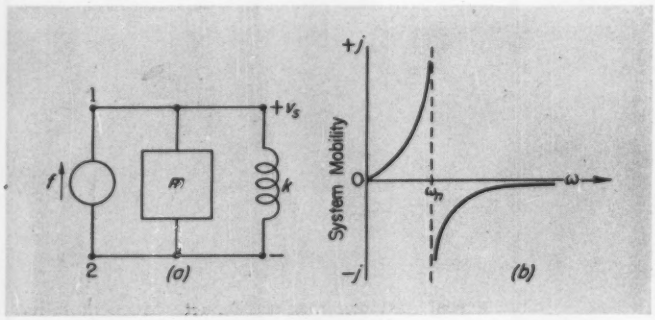


Fig. 10—Force-excited system with a mass and a spring in parallel. Circuit diagram is shown at *a*, frequency plot of mobility across points 1 and 2 of circuit at *b*.

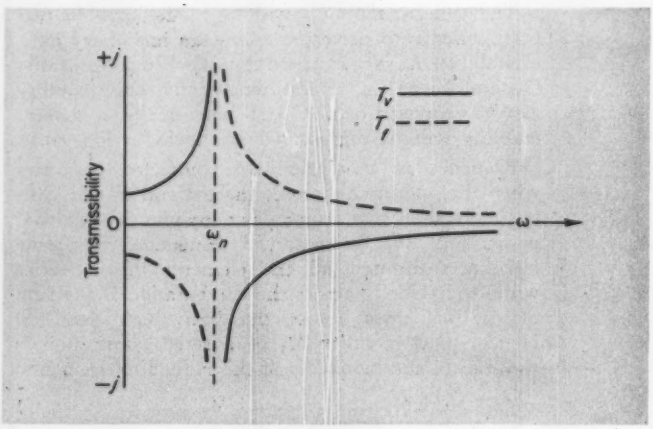


Fig. 11—General transmissibility plot for systems in Fig. 9 and 10.

be plotted for both systems as shown in Fig. 11. This analysis, which can be handled easily with mobility techniques, is extremely complex by the classical method, using differential equations.

The two problems just solved may also be tackled by a slightly different mathematical approach. In the series arrangement, Fig. 9, by definition $v = fM_t$ and $v_m = fM_m$. Hence

$$T_v = \frac{v_m}{v} = \frac{M_m}{M_t} = \frac{\dfrac{-j}{\omega m}}{\dfrac{j\omega}{k} - \dfrac{j}{\omega m}}$$

$$= \frac{1}{1 - \left(\dfrac{\omega}{\omega_n}\right)^2} \qquad (16)$$

The result is the same as before. But what happened? In Equation 16, note that velocity v_m across the mass is equal to input velocity v times the ratio of mobility M_m of the mass to total mobility M_t of the system. In other words, the velocity drop across any element in a series system is proportional to the ratio of element mobility to total mobility.

In the second system, Fig. 10, by definition, $f = v/M_t$ and $f_s = v/M_s$. Then,

$$T_f = \frac{f_s}{f} = \frac{M_t}{M_s} = \frac{\dfrac{j\omega}{k}}{1 - \left(\dfrac{\omega}{\omega_n}\right)^2}$$

$$= -\left[\frac{1}{1 - \left(\dfrac{\omega}{\omega_n}\right)^2}\right] \qquad (17)$$

Thus, the forces in a parallel circuit tend to divide proportionally in the ratio of total parallel mobility to individual branch mobility.

Two general laws can be developed from these simple examples.

1. Force Law: The sum of all of the forces acting on any junction point in a mechanical network is equal to zero.

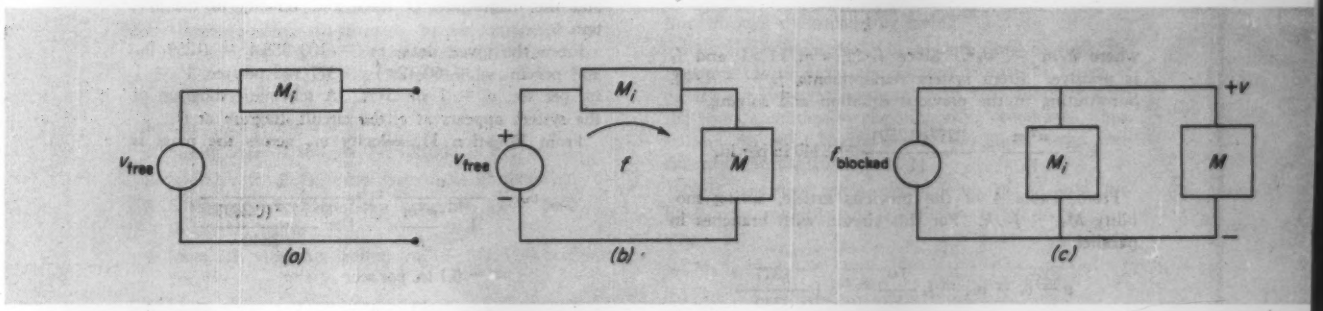


Fig. 12—Effect of internal mobility M_t of practical exciters on mechanical network relationships. Circuit diagrams are based on Thevenin's theorem and show equivalent systems with ideal exciters. In velocity-excited circuit, *a*, internal mobility of practical exciter is in series with velocity produced by ideal exciter when its terminals are unconnected. Force flow in this circuit is shown at *b*. In force-excited circuit, *c*, the force produced through an immovable object by ideal force exciter is in parallel with internal mobility of practical exciter.

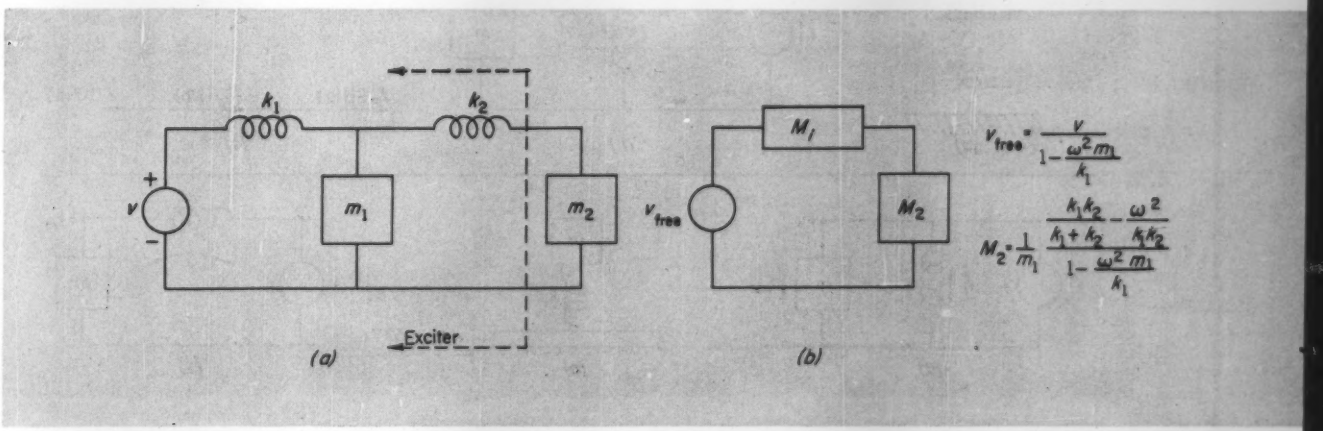


Fig. 13—Analysis of mechanical network using Thevenin's theorem to reduce system complexity. Actual network is shown at *a*, reduced circuit and "reduction" equations at *b*.

Typical Network Calculations

Simple Force-Excited System

A rigid member weighs 100 lb and is constrained to move along a fixed path. It is connected to a solid foundation by a resilient support. An oscillating force of 10 lb acts on the rigid member. Frequency of oscillation is 60 cps. Find the required spring rate of the support to limit the force transmitted to the foundation to 1 lb.

Force transmitted to the foundation is the force, f_s, through the spring. From the given data, $m = 100/386.4 = 0.259$ lb-sec^2 per in., $\omega = 60\ (2\pi) = 377$ rad per sec, $f_s = 1$ lb, $F = 10$ lb, and $f = 10 \sin 377t$. A schematic diagram of the system appears at *a*, the circuit diagram at *b*.

Equation 15 for force transmissibility can be expressed as

$$T_f = \frac{f_s}{f} = \frac{1}{\frac{\omega^2 m}{k} - 1}$$

where $k/m = \omega_n^2$. Since $f_s < f, (\omega^2 m/k) > 1$ and f_s is positive. From system requirements, $f_s/f = 1/10$. Substituting in the previous equation and solving,

$$k = \frac{\omega^2 m}{11} = \frac{377^2(0.259)}{11} = 3340 \text{ lb per in.}$$

From Table 4 of the previous article, spring mobility $M_s = j\omega/k$. For this circuit, with branches in parallel,

$$v = v_s = v_m = f_s \frac{j\omega}{k} = +1 \frac{j377}{3340}$$

$$= +j0.113 \text{ in. per sec}$$

Mobility of a mass element is $M_m = -j/\omega m$. Thus,

$$f_m = \frac{v}{\frac{-j}{\omega m}} = \frac{+j0.113}{\frac{-j}{377(0.259)}} = -11 \text{ lb}$$

The complex-vector diagram of forces in the system may be drawn directly, *c*, using exciting force f as the reference. Relative directions of force flow and velocity may now be added to the circuit diagram, as shown at *d*, to complete the final detail of the problem solution.

Simple Velocity-Excited System

A rigid member weighs 100 lb and is constrained to move along a fixed path. It is mounted to a resilient support, having a spring rate of 3340 lb per in. This system is connected to a structure that is moving with a velocity of 1 in. per sec at a frequency of 60 cps. Find the velocity transmissibility and the magnitudes of force and velocity in the system.

From the given data, $m = 100/386.4 = 0.259$ lb-sec^2 per in., $\omega = 60\ (2\pi) = 377$ rad per sec, $V = 1$ in. per sec, $v = 1 \sin 377t$. A schematic diagram of the system appears at *e*, the circuit diagram at *f*.

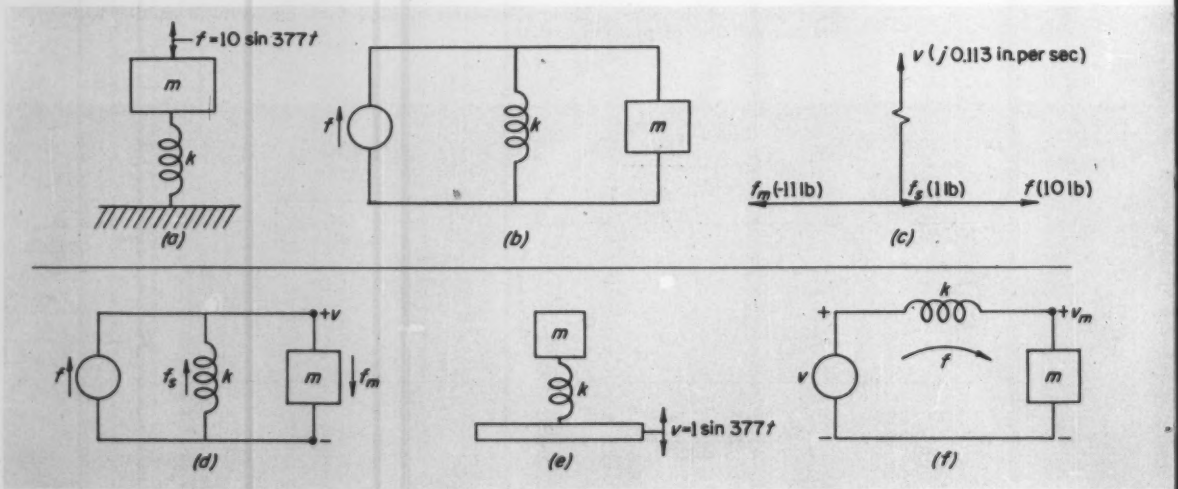
From Equation 11, velocity v_m across the mass is

$$v_m = \frac{v}{1 - \frac{\omega^2 m}{k}} = \frac{1}{1 - \frac{377^2(0.259)}{3340}}$$

$$= -0.1 \text{ in. per sec}$$

For this series arrangement, velocity v_s across the spring is

$$v_s = v - v_m = 1 - (-0.1) = 1.1 \text{ in. per sec}$$



Also,

$$f = f_s = f_m = \frac{v_m}{M_m} = \frac{v_m}{\frac{-j}{\omega m}} = \frac{-0.1}{\frac{-j}{377(0.259)}}$$

$$= -j\,9.75 \text{ lb}$$

A complex-vector diagram of forces and velocities in the system, using the exciting velocity as a reference, is shown at g.

Vibrating-Roller Suspension

A road-tamping device is shown at h. The vibrating roller is driven by a variable-frequency force exciter which is tuned to put the mass of the roller and the springiness of the soil in resonance. The vibrating roller is excited only in the vertical direction and the supporting frame is relatively long so that all vertical motions are nearly translational. The entire vibrating-roller structure is to be supported by spring mounting. Find the required spring rate to isolate 98 per cent of the roller motion from the supporting frame.

System parameters are:

1. Spring rate of soil, k_1 = 123,000 lb per in.
2. Spring rate of isolation system, k_2 (unknown).
3. Spring rate of drive-motor assembly, k_3 = 2600 lb per in.
4. Mass of vibrating roller, m_1 = 9.15 lb-sec^2 per in.
5. Mass of supporting frame, m_2 = 7.95 lb-sec^2 per in.
6. Mass of drive-motor assembly, m_3 = 2.07 lb-sec^2 per in.
7. Peak magnitude of exciting force, F = 15,000 lb.
8. Frequency of oscillation of exciting force, ω = 167 rad per sec.

Damping in the system is assumed to be negligible. A schematic diagram of the system is shown at i, circuit diagram at j.

Since roller motion is to be isolated, the problem is to find the value of spring rate k_2 which will give a velocity transmissibility, T_v = 0.02. First step is to reduce each circuit group to an equivalent single mobility until the simplest equivalent circuit for the system is obtained.

Consider first the parallel combination of k_1 and m_1. These elements represent the resonant combination of the roller and the soil. At resonance, the mobility of the combination is infinite. Hence, theoretically, zero force is required to maintain this condition. That is, all of the force driving the roller must flow through the supporting spring.

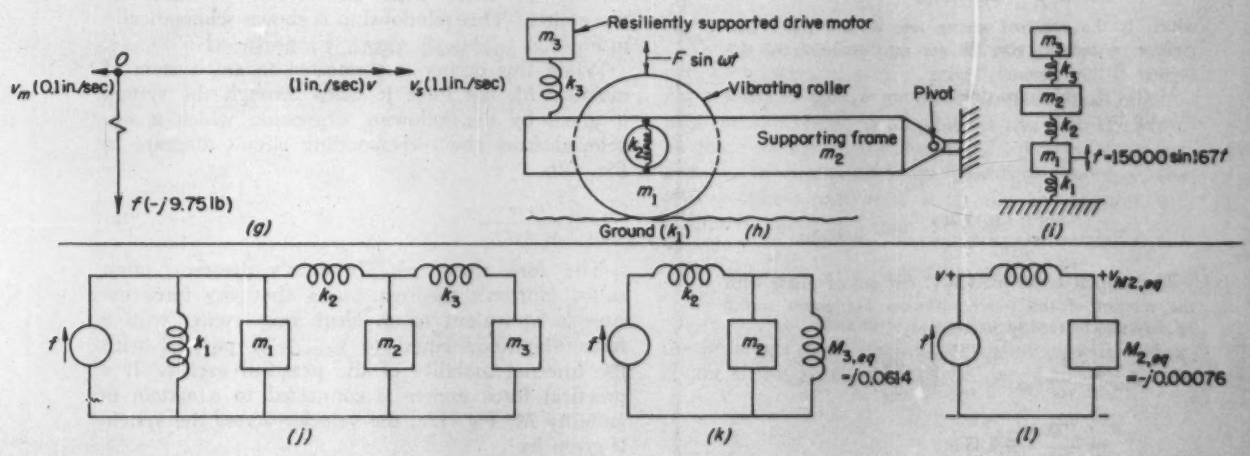
Actually, some force will always flow through the resonant circuit from the exciter because of losses or damping. However, assumption of zero damping gives the worst condition in the supporting structure. Thus, k_1 and m_1 may be completely eliminated from consideration in the circuit.

Next, consider series combination of k_3 and m_3. Equivalent mobility $M_{3,eq}$ for this group is

$$M_{3,eq} = \frac{j\omega}{k_3} + \frac{-j}{\omega m_3} = \frac{j167}{2600} - \frac{j}{167(2.07)}$$

$$= j\,0.0614$$

Hence, the drive motor and supporting spring combination have the characteristic of a simple spring at



Typical Network Calculations

$\omega = 167$ rad per sec. The equivalent circuit at this point is shown at *k*.

Consider now the parallel combination of m_2 and $M_{3,eq}$. Equivalent mobility $M_{2,eq}$ for this combination is

$$M_{2,eq} = \frac{1}{\frac{1}{\frac{-j}{\omega m_2}} + \frac{1}{M_{3,eq}}}$$

$$= \frac{1}{\frac{1}{\frac{-j}{167(7.95)}} + \frac{1}{j0.0614}} = -j\,0.00076$$

This combination has the characteristic of a simple mass at $\omega = 167$ rad per sec. The final equivalent circuit is shown at *l*. Thus, the motion or displacement of the supporting structure is the same as that for the equivalent mobility, $M_{2,eq}$. Therefore, this motion is proportional to the velocity, $v_{M2,eq}$, across $M_{2,eq}$. This velocity is

$$v_{M2,eq} = fM_{2,eq} = f(-j\,0.00076)$$

Also, from the circuit diagram, *l*,

$$v = f\left(\frac{j\omega}{k_2} - j\,0.00076\right)$$

By definition,

$$T_v = \frac{v_{M2,eq}}{v} = \frac{-j\,0.00076}{\frac{j\omega}{k_2} - j\,0.00076} = -0.02$$

Solving this equation for k_2,

$$k_2 = \frac{0.02\,\omega}{0.00076 + 0.02(0.00076)} = 4300 \text{ lb per in.}$$

which is the required spring rate of the roller suspension system to give 98 per cent isolation of the motion of the roller.

Motion d_{m2} of supporting structure m_2 may be found directly from

$$d_{m2} = \frac{1}{j\omega} v_{m2} = \frac{1}{j\omega} f v_{M2,eq}$$

$$= \frac{15000(-j\,0.00076)}{j\,167} = -0.069 \text{ in.}$$

The motion across m_2 is 180 deg out of phase with the motion of the roller. Motion d_{k2} across spring k_2 may also be readily determined;

$$d_{k2} = \frac{1}{j\omega} v_{k2} = \frac{1}{j\omega}\left(f\frac{j\omega}{k_2}\right) = \frac{f}{k_2}$$

$$= \frac{15000}{4300} = 3.45 \text{ in.}$$

2. VELOCITY LAW: The sum of all of the velocities across the various elements in any closed mechanical loop is equal to zero.

These laws are sometimes referred to as the junction or node law and the loop law. They are descriptive of the mechanical equations which result in the analysis of the mechanical system, and are analogous to Kirchhoff's law in electricity. Several other theorems are also important in mechanical network analysis.

Thevenin's Theorem: So far, force and velocity exciters have been considered as ideal mathematical entities. Actually, there is a limit to the velocity with which a practical exciter can move its terminals even if unconnected. As a result, a practical force exciter cannot transmit as much force through a system of high mobility as through a system of low mobility. Similarly, a practical velocity exciter is limited in the velocity it can develop across a mechanical system. It can produce more velocity across a system of high mobility than across a system of low mobility.

Every practical exciter has some mass, some spring rate and some damping internally. The result is an internal mobility which limits the practical force or velocity any exciter can produce.

The internal mobility, M_i, of an exciter is defined as the ratio of velocity which it can produce across its terminals when it is not connected, to force which it can produce through an immovable object. Mathematically,

$$M_i = \frac{v_{free}}{f_{blocked}} \qquad (18)$$

The velocity form of Thevenin's theorem states that any exciter is equivalent to an ideal velocity exciter with a velocity amplitude equal to the free velocity in series with the internal mobility of the exciter. This relationship is shown schematically in Fig. 12*a*.

When this exciter is connected to any system of mobility *M*, the force it sends through the system is given by the following expression which is developed from the corresponding circuit diagram in Fig. 12*b*:

$$f = \frac{v_{free}}{M + M_i} \qquad (19)$$

The force form of Thevenin's theorem, often called Norton's theorem, states that any force exciter is equivalent to an ideal force exciter with a force amplitude equal to $f_{blocked}$ in parallel with the internal mobility of the practical exciter. If a practical force exciter is connected to a system of mobility *M*, Fig. 12*c*, the velocity across the system is given by

$$v = f_{blocked}\left(\frac{1}{\frac{1}{M_i} + \frac{1}{M}}\right) \qquad (20)$$

These laws permit even a complicated portion of a system to be considered as part of the exciter when calculating the internal mobility of the aggregation. The sequence of reducing a complicated system is shown in Fig. 13.

Reciprocity Theorem: Consider the general mechanical network shown in Fig. 7. If a force, that can be considered ideal, is connected between terminals *A* and *B* of this mechanical system, it will produce a certain velocity, *v*, between terminals *C* and *D*. Then, if that same force is connected between *C* and *D*, it will produce the same velocity, *v*, both in magnitude and phase, between terminals *A* and *B*.

Similarly, if an ideal velocity source is imposed in series with arm *AB*, it will produce a certain force *f* through arm *CD*. The same force *f* will be produced through arm *AB* if the velocity source is connected in series with arm *CD*. This law is the generalized theorem for the examples previously presented where it was shown that the velocity transmissibility in one direction is equal to the force transmissibility in the other direction. This theorem may be used to compute the vibration which will be transmitted in one direction through a mechanical system by a force or velocity when the force or velocity transmitted in the other direction is known. In general this theorem is valid for excitations of any wave form, as well as for both transient and forced vibrations.

Principle of Superposition: This particular theorem has been mentioned previously but a more general statement may be helpful. Consider a typical mechanical network in which a number of force and velocity exciters are acting simultaneously in various parts of the system. The principle of superposition states that the instantaneous forces and velocities produced in the different parts of the system are simply the sum of the instantaneous forces and velocities which the separate exciters would produce acting alone. For practical exciters, the vibration produced by one of the exciters acting alone may be computed properly only if the internal mobilities of all of the other exciters remain connected to the system. Effectively, only the exciters are removed or blocked out when the effects of a single exciter are examined.

Problem Examples: Calculations in the solution of problems by mobility techniques are demonstrated in *Typical Network Calculations*.

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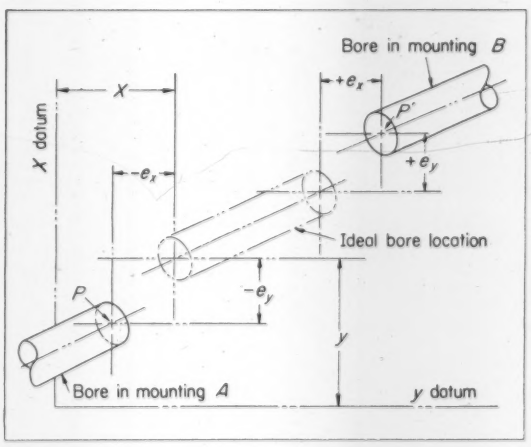
Tips and Techniques

Location of Shaft Bearings



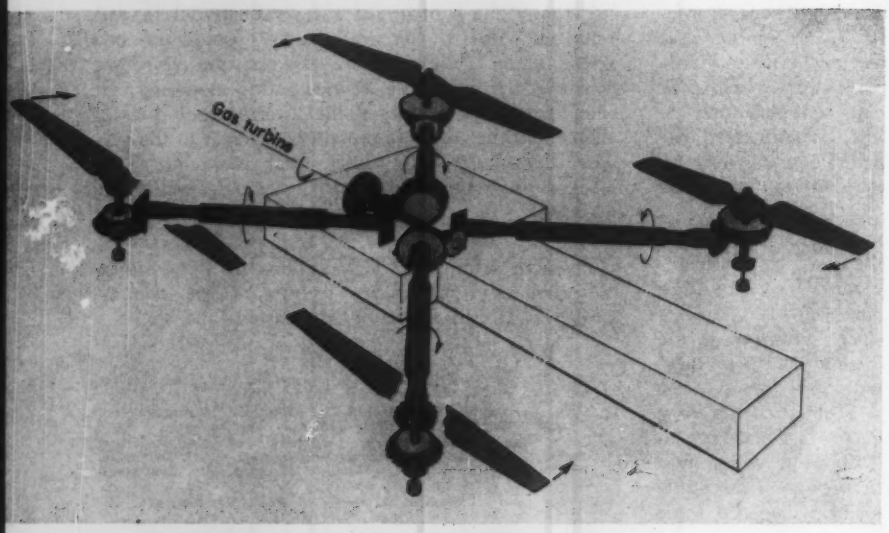
When the bearings of a shaft are located in separate mountings, *A* and *B*, misalignment of the bearing centers, *P* and *P'*, will occur if the two mountings are not clamped together at the time the bores of these bearings are machined. When it is not possible to clamp the two mountings together, the plus-or-minus tolerance *e* in the rectangular coordinates used to locate each bore is

$$e = \frac{d}{2.8}$$

where *d* is the maximum permissible error by which the bearing centers may be out of alignment.—MAX FOGIEL, *New York 17, N. Y.*

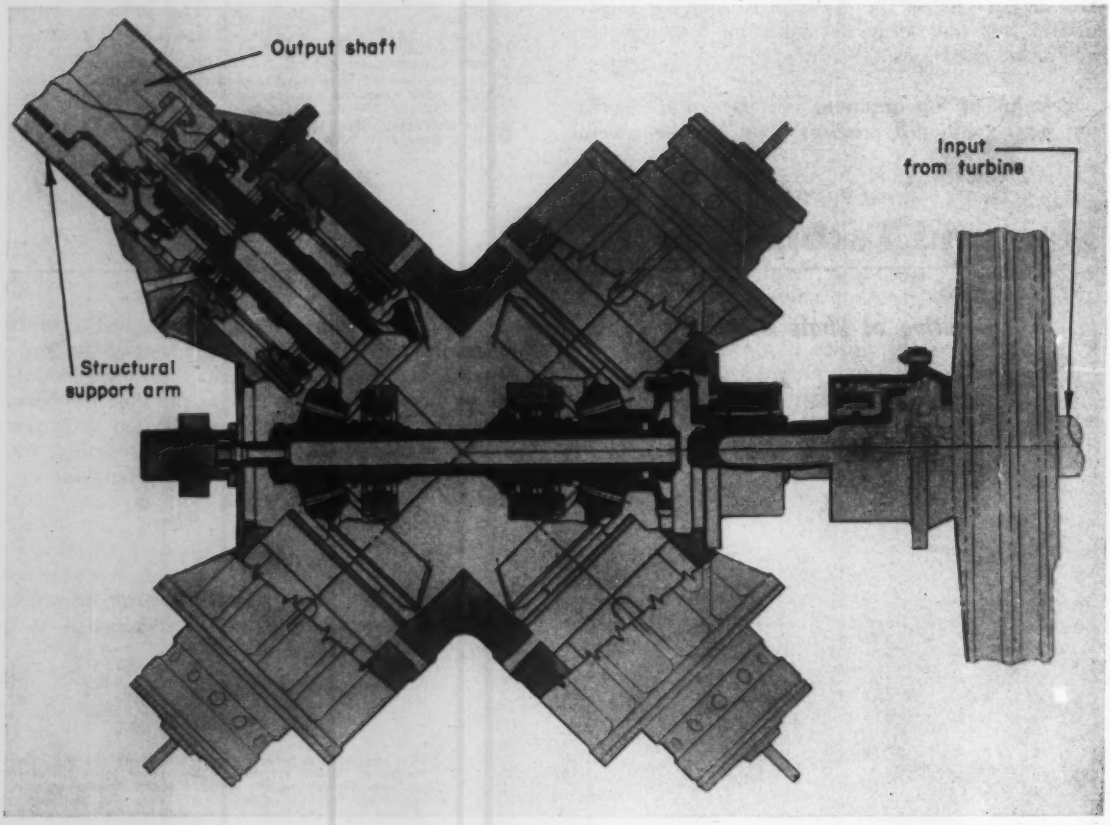
Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Flying Jeep Saves Weight With



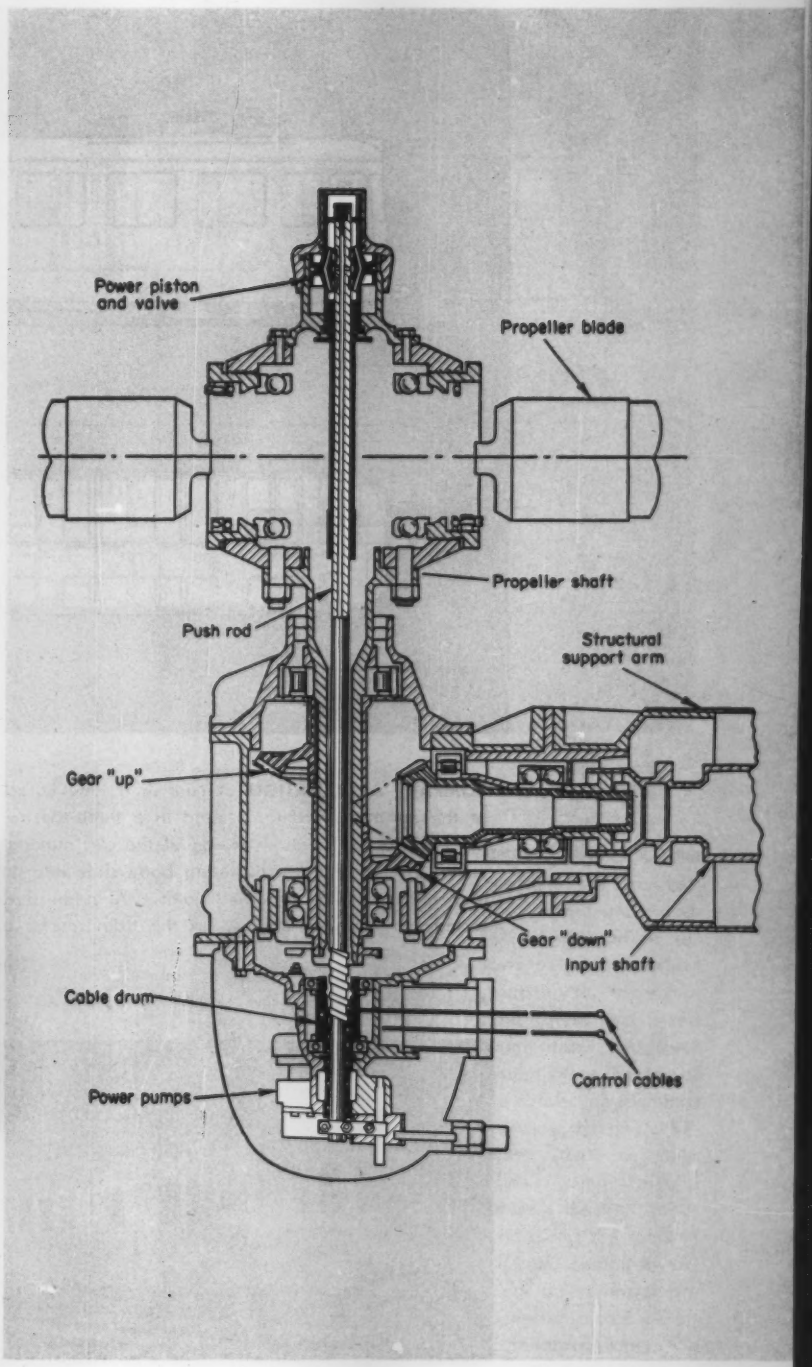
TRANSMISSION AND SPEED REDUCER for an unusual four-fan VTOL craft reduces the powerplant's 6000 rpm to 2150 rpm for each of the four props. Gears are arranged so that no two adjacent fans rotate in the same direction. Gearbox is part of the structural framework, and turbine exhaust contributes to forward thrust.

FACING GEARS ON DRIVESHAFT cancel end thrust, making possible smaller bearings.



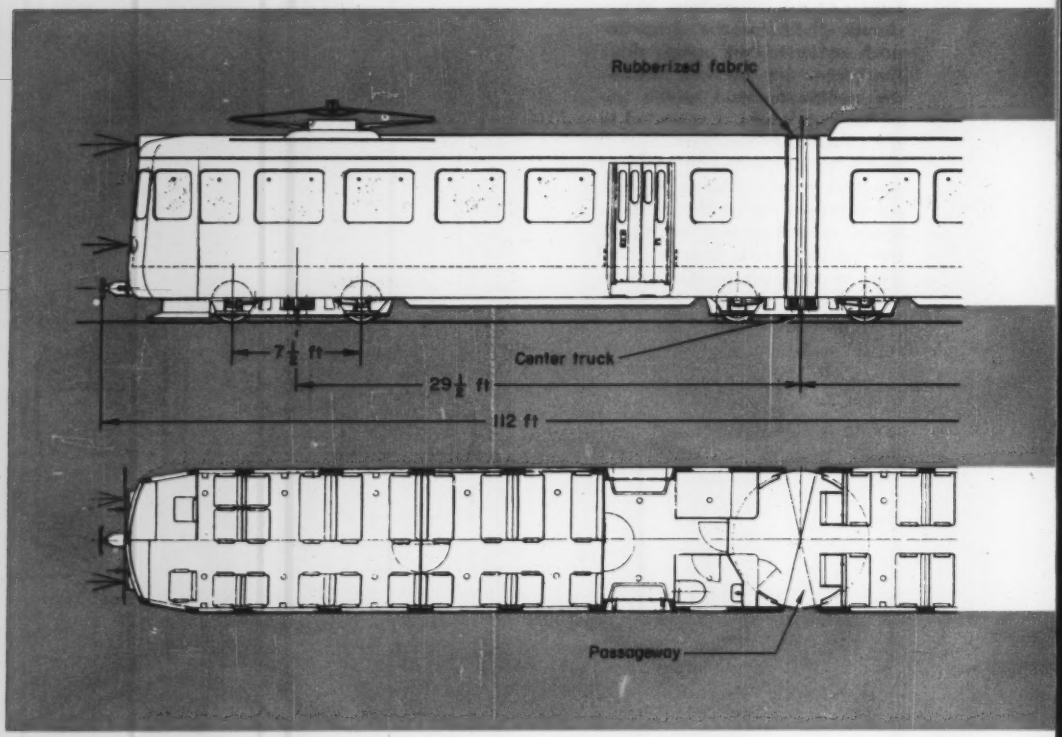
Opposing Gears and Dual-Purpose Oil

LUBRICATING OIL doubles as hydraulic fluid for the propeller pitch controls. Two pumps drive fluid from the reservoir through the hollow pushrod to the top of the hub where it is ported to a hydraulic servomechanism that keeps the power piston centered on ports in the pushrods. A cable drum moves the pushrod up or down to desired position by revolving around its threaded portion as actuated by the control cable.



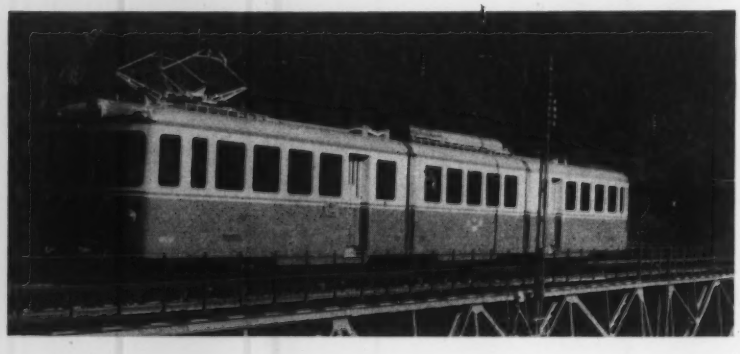
Curtiss-Wright developed Aerial Platform model VZ-7AP under contract with the Army Transportation Research and Engineering Command (TRECOM), Ft. Eustis, Va. Gears and propeller-pitch servo units were developed for Curtiss-Wright by Sargent Engineering Corp. Powerplant is Continental's 425-hp Artouste Turbomeca IIB shaft turbine. Rudder in the turbine exhaust controls yaw.

Cars Share Common Truck

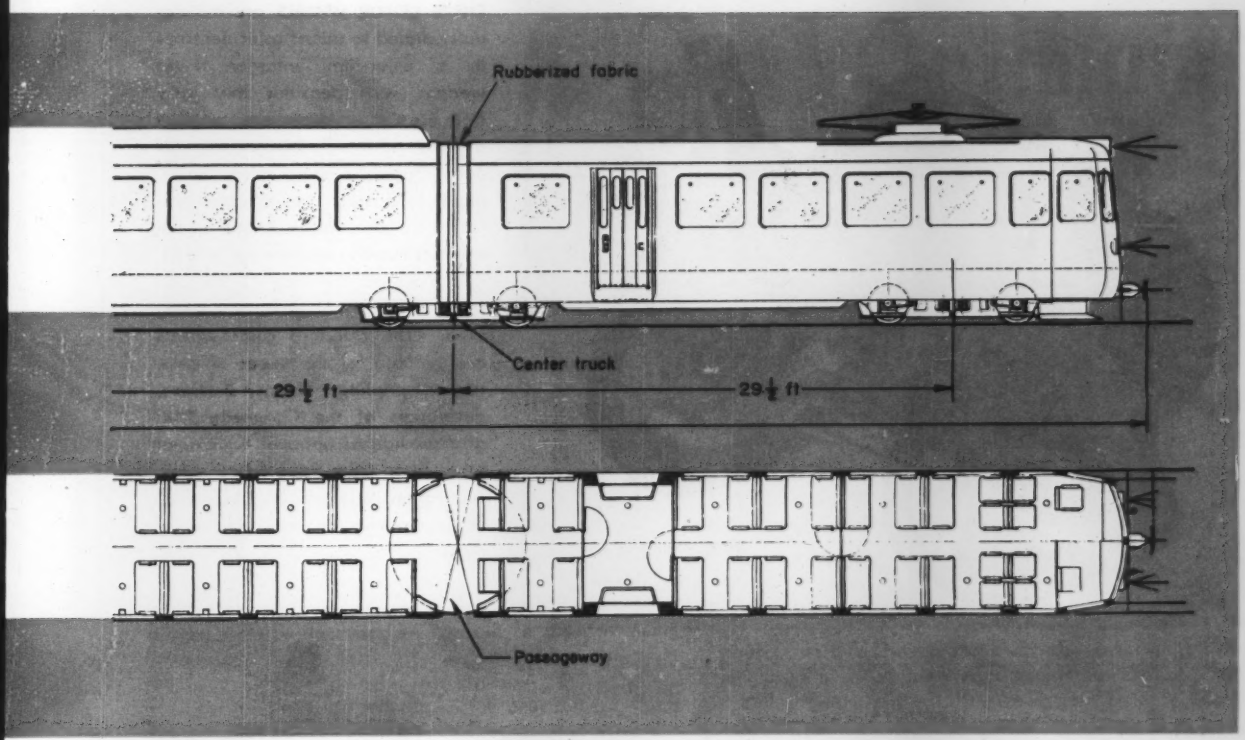


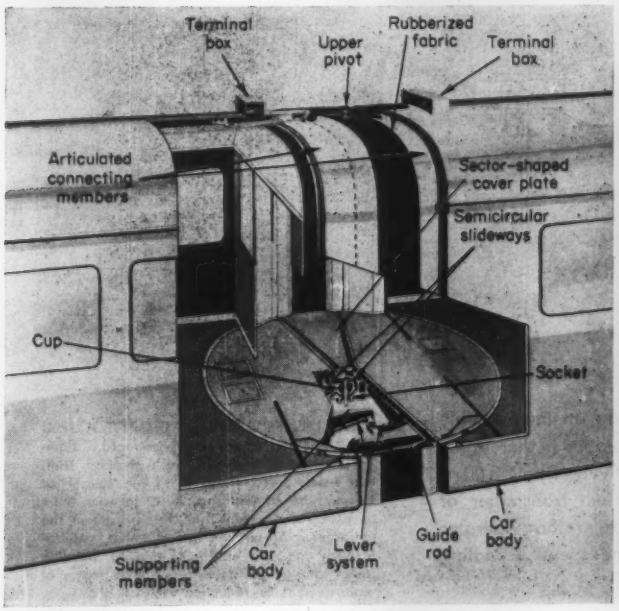
COMPACT ARTICULATION of cars in a new European train eliminates two of the six trucks ordinarily used in a three-car train. A separate articulating body becomes an extension of the car, making room for four additional seats. Walls of the articulating body slide into the main car body at each end with a weather-sealed joint. A rubberized fabric portion absorbs changes in angular position as the train rounds curves.

Articulated train was developed by Schindler Waggon AG, Pratteln, Switzerland.



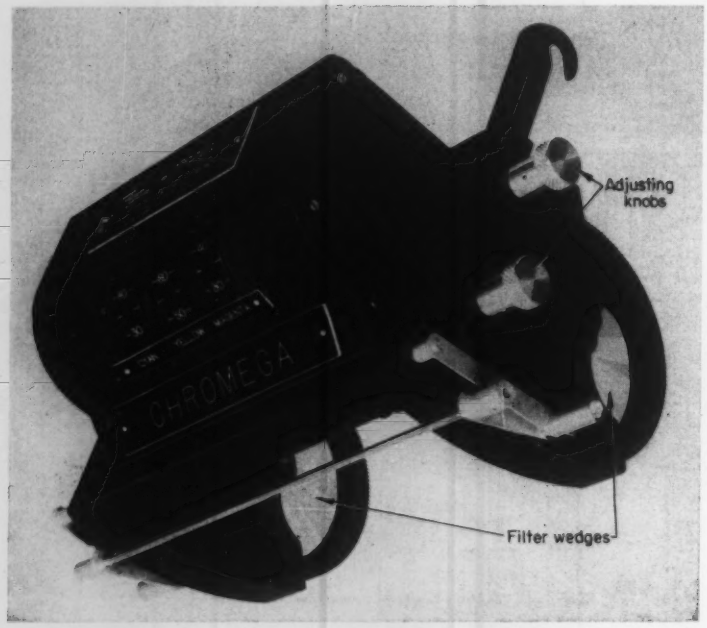
In Articulated Train



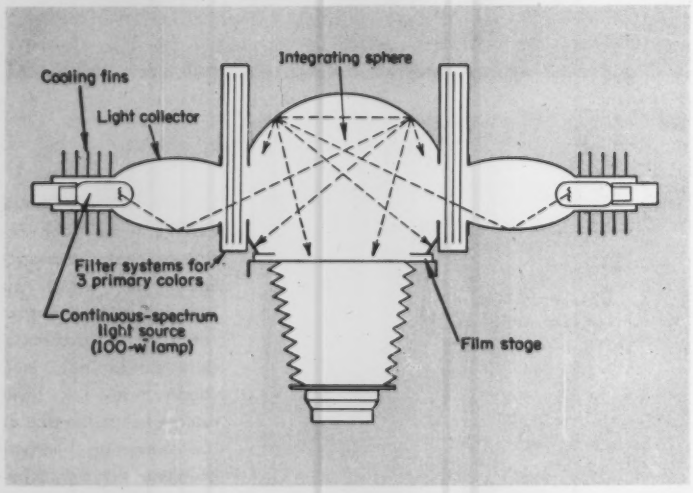


SECTOR-SHAPED COVER PLATES in the floor section conceal a cup-and-socket joint which allows lateral and vertical rotation to accommodate curves, hills, and rough track. A lever system keeps the axis of the connecting members bisecting the angle between the car axes when going around curves. Electric leads pass along the roofs of the cars, ending in terminal boxes which are connected across the articulation by cable.

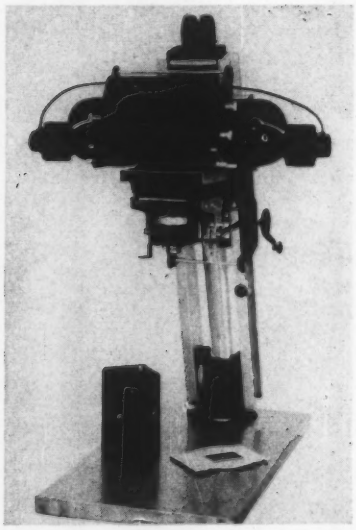
New Enlarger Dials Color Changes



THREE COLOR WHEELS are individually dialed to adjust color densities in a color-film enlarger. Filter wedges with densities that vary from each other in discrete steps are assembled into wheels—one for each "minus" primary color. Entering light passes through ports protected by the filters. Knobs on the external housing operate the wheels, and dials on the face of the unit indicate density of each color being used. The standard color wheels are suitable for the needs of color reversal printing. Simmon Brothers, developers of the Chromega D-4, also provide as optional equipment other filter units adapted to color-separation printing or black-and-white printing on variable-density paper.

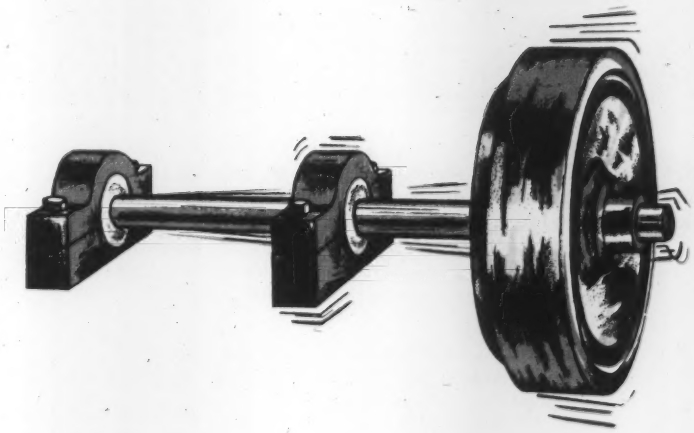


INTEGRATING SPHERE MIXES LIGHT obtained by dialing an intermediate position of the color wheel. Light from parts of two wedges is thoroughly mixed to give any desired intermediate tint. Relatively small 100-w lamps are used because the sphere is a more efficient transmitter of light than most diffusers. The result is a color enlarger that operates with less heat than other color enlargers of the same speed. Cooling fins on light collectors help dissipate lamp heat.



ALL LENSES ARE FACTORY-FOCUSED exactly 1 in. above the baseboard. Commercial easels are 1 in. thick or less. Thinner easels are shimmed up to 1-in. height for proper use of autofocus. A focusing cam is provided for each lens to be used in the enlarger. Three can be mounted simultaneously on the enlarger, making possible quick change of lenses for a wide range of enlargement or reduction ratios.

Like death and taxes, critical speeds can't be eliminated. But they don't hurt if they can be pushed above the expected operating speed. One technique that can help do this trick is to pick . . .



Optimum Bearing Locations

. . . for maximum critical speed

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Analytical Dynamics Group Leader
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Stratford, Conn.

VIBRATION problems with rotating shafts become more troublesome as machine speeds increase. A partial solution has been to reduce flexibility of bearing supports. But, as speeds have continued to increase, even the flexibility of bearings themselves cannot be ignored in some rotating machines. Not much can be done about this part of the problem, at least at this time.

Another attack is to place the bearings of those locations which will be most advantageous from the standpoint of vibration. This article presents a method for determining the optimum distance between bearing locations for an overhung flexible shaft on flexible supports, Fig. 1. Although only one specific type of shaft arrangement is considered, this method can be extended and applied to any rotating shaft design.

Method of Attack: It is desirable, although not always feasible, to design a shaft system so that the first critical speed is above the required operating range. The first critical speed is influenced by the distance between bearing centers in the case considered here: An overhung shaft, supported at two points, with a heavy mass on the overhang, subjected to a speed high enough to require that support or bearing flexibility be considered. A heavy mass is defined as one that is much greater than the mass of the shaft.

Since the natural frequency of the system is inversely proportional to the static deflection of the mass, the problem is to find the arrangement which has as small a static deflection as possible.

Deflection of the mass is affected by the support flexibility and the shaft flexibility. For a particular ratio of these flexibilities, deflection of the mass will be a minimum for one specific distance between supports. Maximum first critical speed results with this optimum distance.

Deflection of Mass: Effects of the support and shaft flexibilities on deflection of the mass can be

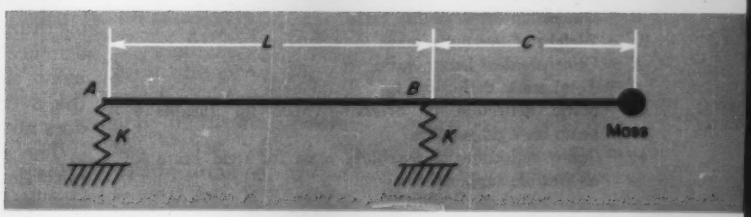


Fig. 1—Heavy mass on an overhung shaft which is supported at two points.

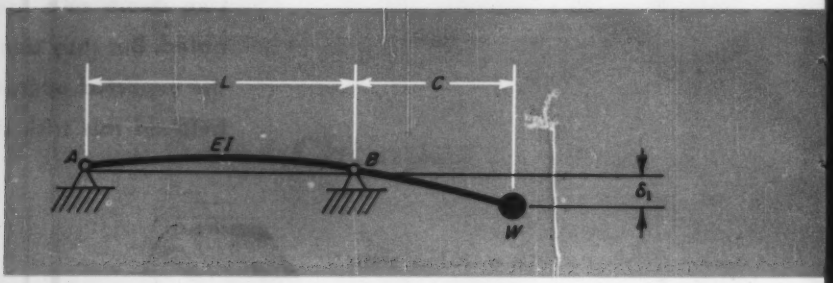


Fig. 2—Deflection due to shaft flexibility.

calculated separately, and then combined by superposition. First, assume that the shaft is flexible, and mounted on rigid supports, Fig. 2. Hence, the static deflection is (see Nomenclature)

$$\delta_1 = \frac{W}{EI}\left(\frac{C^3}{3} + \frac{C^2L}{3}\right) \tag{1}$$

Next, assume that the system is composed of a rigid shaft on flexible supports, Fig. 3. The static reaction forces are: At A,

$$\text{Force} = \frac{WC}{L} \tag{2a}$$

At B,

$$\text{Force} = \frac{W(L+C)}{L} \tag{2b}$$

The static deflection of this arrangement is obtained by using the same spring constant K at both supports:

$$\delta_2 = \frac{W}{K}\left(\frac{L^2 + 2CL + 2C^2}{L^2}\right) \tag{3}$$

Hence, by superposition, the total deflection is

$$\Delta = \delta_1 + \delta_2 = \frac{W}{EI}\left(\frac{C^3}{3} + \frac{C^2L}{3}\right) + \frac{W}{K}\left(\frac{L^2 + 2CL + 2C^2}{L^2}\right) \tag{4}$$

As the figures and equations show, for a flexible beam on rigid supports, static deflection of the weight increases as the length is increased. Conversely, for a rigid beam on flexible supports, an increase in the bearing distance decreases the deflection. Thus, there must be an optimum distance between bearings—a distance that will produce a minimum deflection for a particular flexible beam on flexible supports. This optimum value can be calculated.

Optimum Locations: If all of Equation 4 is multiplied and divided by C^3, and if the last quantity is multiplied and divided by EI,

$$\Delta = \frac{WC^3}{EI}\left[\frac{1}{3} + \frac{L}{3C} + \frac{EI}{KC^3}\left(\frac{L^2 + 2CL + 2C^2}{L^2}\right)\right] \tag{5}$$

Next, introduce $x = L/C$ and $R = EI/KC^3$. Length ratio x is self-explanatory. Nondimensional factor R reflects the ratio of support flexibility $1/K$ to shaft flexibility C^3/EI.

When x and R are substituted in Equation 5,

$$\Delta = \frac{WC^3}{EI}\left[\frac{1}{3} + \frac{x}{3} + R\left(1 + \frac{2}{x} + \frac{2}{x^2}\right)\right] \tag{6}$$

To find an optimum value for the length ratio, the deflection is differentiated with respect to x. The constant $W\ C^3/EI$ is ignored and differentiation produces a relation between R and x:

$$R = \frac{x^3}{6x + 12} \tag{7}$$

A plot of R versus x is shown in Fig. 4. This plot is used to select distance L for fixed values of C, E, I, and K. This value of L gives the lowest static deflection and, hence, the highest natural frequency.

The derivation of Equation 7 reveals that the flexibility of the overhanging part of the shaft has no effect on the curve, Fig. 4. Therefore, if a shaft is designed with a different diameter at the overhang than between the bearings, the diameter of the overhung portion can be ignored when an optimum distance between bearings is determined. This statement should not be misinterpreted. Flexibility of the overhang does affect the critical speed, but it does not affect the optimizing of the support location.

The graph, Fig. 4, is most useful when the support flexibility is known or can be estimated and the optimum bearing locations are desired. In most

Nomenclature

- A = Support location
- B = Support location
- C = Overhung dimension, in.
- E = Young's modulus of elasticity, psi
- I = Shaft cross-sectional area moment of inertia, in.^{4}
- K = Spring constant, lb per in.
- L = Distance between support locations, in.
- R = Dimensionless flexibility ratio
- W = Weight of overhung mass, lb
- X = Dimensionless length ratio
- Δ = Total static deflection, in.
- δ_1 = Static deflection of overhung mass for flexible beam on rigid supports, in.
- δ_2 = Static deflection of overhung mass for rigid beam on flexible supports, in.

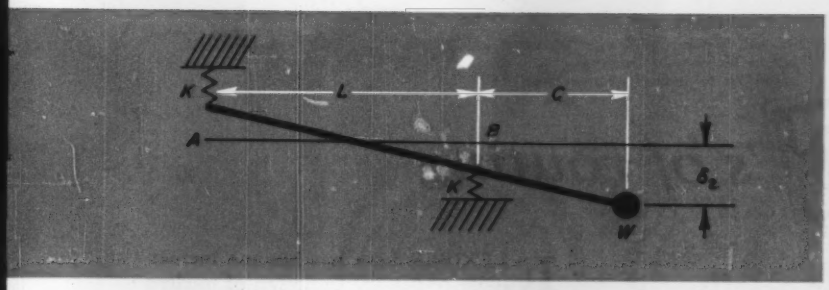


Fig. 3—Deflection due to support flexibility.

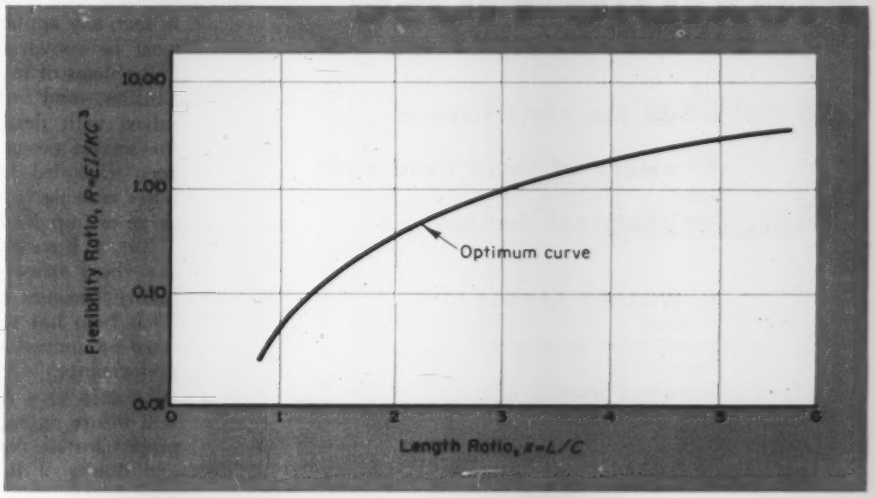


Fig. 4—Chart for determining optimum bearing locations.

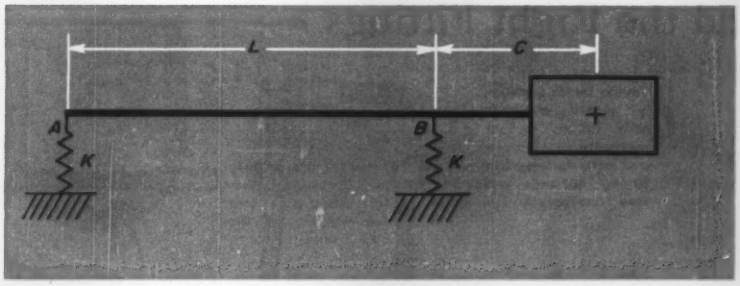


Fig. 5—Heavy rotor on overhung shaft supported by two bearings.

practical problems, the relative flexibility need not be too accurate, since a small change in this value will not appreciably affect the value of L/C.

Most designs are made as rigid as possible. Therefore, support flexibilities are usually small when compared to shaft flexibilities. A reasonable ratio is 1/3. For this ratio, the optimum value for L/C, Fig. 4, is approximately 2. Hence, distance L should be twice the length C for optimum design. This result is consistent with practical design experience. The natural frequency of a system with arbitrarily placed bearings might be shifted as much as 10 to 20 per cent by optimizing these bearing locations.

Example: Assume that a rotor can be represented by a flexible shaft, without mass, supporting a heavy mass, without flexibility, and that the mass must overhang the shaft supports. The shaft is steel and the moment of inertia of the cross-sectional area is determined from torque carrying (stress) considerations. The bearing and supporting-structure flexibilities are estimated from previous experience, or determined from static measurements. The necessary fixed parameters are: $E = 30 \times 10^6$ psi, $C = 4.0$ in., $K = 2.0 \times 10^6$ lb per in., and $I = 4.136$ in.^{4}

The dimensionless flexibility ratio is

$$R = \frac{EI}{KC^3} = \frac{(30 \times 10^6)(4.136)}{(2 \times 10^6)(64)} = 0.97 \qquad (8)$$

From the curve, Fig. 4, or Equation 7, $x = 2.9$ in. and $L = Cx = 2.9(4.0) = 11.6$ in.

If the distance between support points is 11.6 in., the highest natural frequency of the arrangement will be attained. In this example, the supported mass is quite heavy. Therefore, the shaft is large and the flexibility ratio is relatively large.

ABC's of routing

Flexible Hose

Add the right fittings
Beware of small bend radii
Circumvent torsion

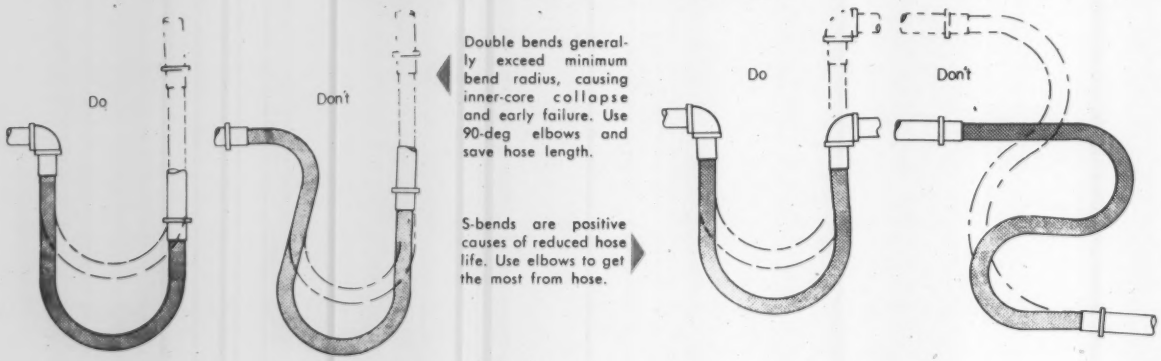
H. WILLIAM LAROSE
Manager
Hose Product Development
Titeflex Inc.
Springfield, Mass.

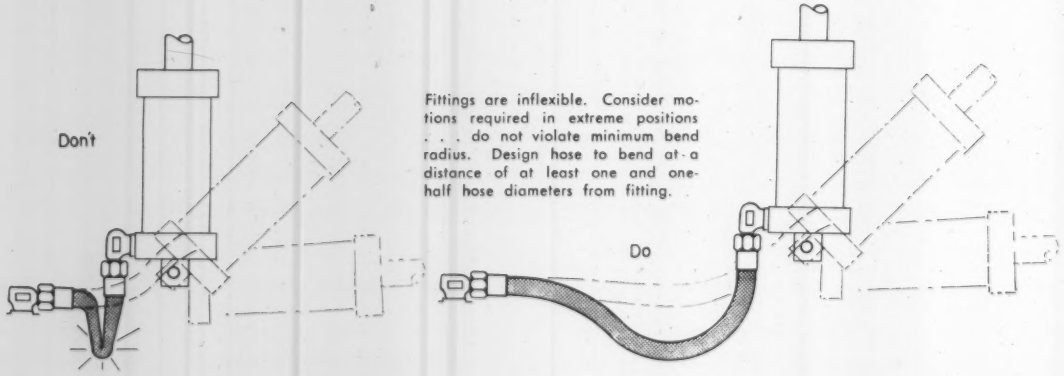
FLEXIBLE hose has become increasingly important in design of modern machine tools, aircraft, missiles, and, in fact, any application where fluid or gas must be conveyed under pressure.

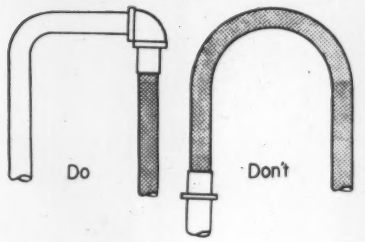
Problems of misalignment, thermal expansion, and vibration can often be solved with flexible hose. In addition, the service range of hose assemblies has been extended by the development of hoses capable of withstanding very high surge or impulse loads.

But, as hose is required to perform under these more severe conditions, any failure becomes correspondingly critical. Each hose has service limitations which must be understood to obtain satisfactory performance. Once the hose is selected, adherence to a few simple ground rules will insure against failure caused by improper installation. Here are some do's and don'ts of flexible hose installation.

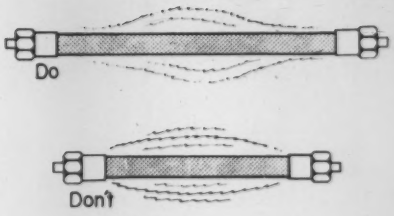
Add the Right Fittings


Do
Don't
Double bends generally exceed minimum bend radius, causing inner-core collapse and early failure. Use 90-deg elbows and save hose length.
S-bends are positive causes of reduced hose life. Use elbows to get the most from hose.
Do
Don't


Don't
Fittings are inflexible. Consider motions required in extreme positions . . . do not violate minimum bend radius. Design hose to bend at a distance of at least one and one-half hose diameters from fitting.
Do

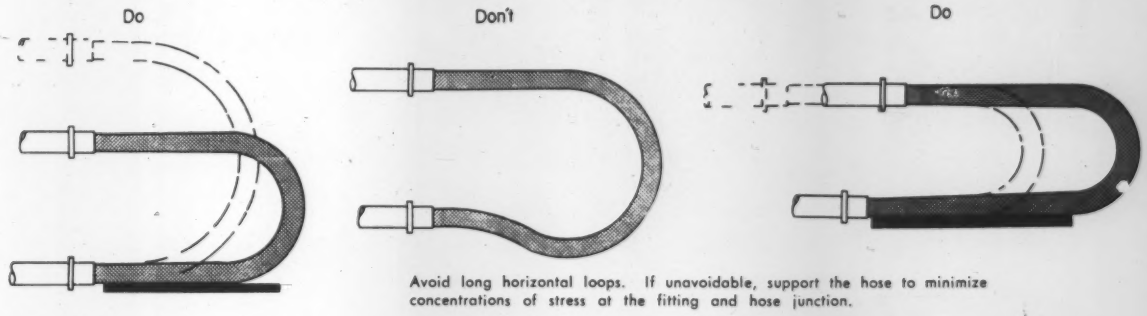


Install hose to insure minimum stress at the connecting point of the fitting. To permit the weight of the hose to cause bending at the fitting is poor design.

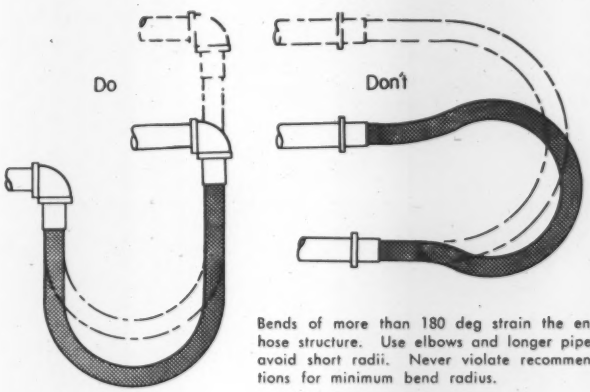


Hose used to isolate vibration should be of sufficient length to allow vibrations to taper off to a straight line before they reach the couplings.

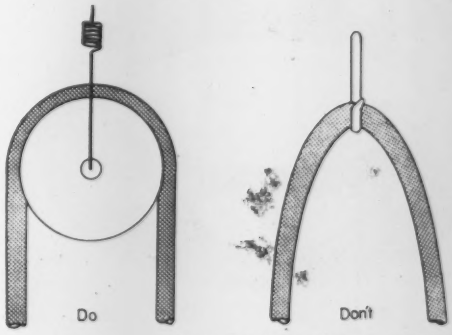
Beware of Small Bend Radii



Avoid long horizontal loops. If unavoidable, support the hose to minimize concentrations of stress at the fitting and hose junction.

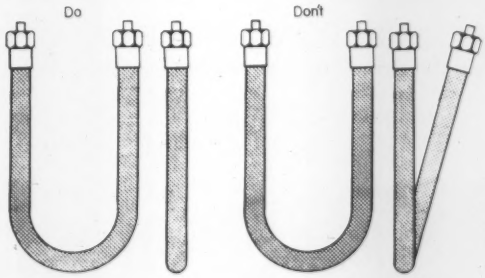


Bends of more than 180 deg strain the entire hose structure. Use elbows and longer pipe to avoid short radii. Never violate recommendations for minimum bend radius.



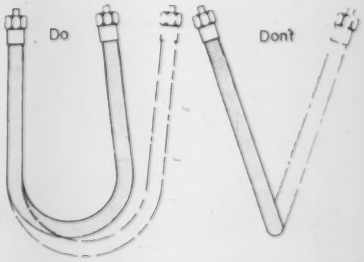
Support a hose wherever possible. But, be sure that the support does not induce sharp bends.

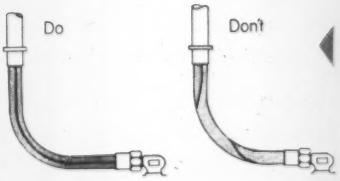
Circumvent Torsion



Out-of-plane fittings cause undue strains and twisting, and hasten failure.

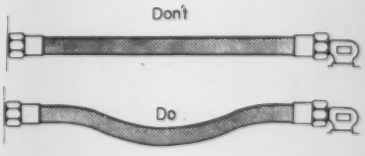
Bending should take place in the plane running through the hose length.

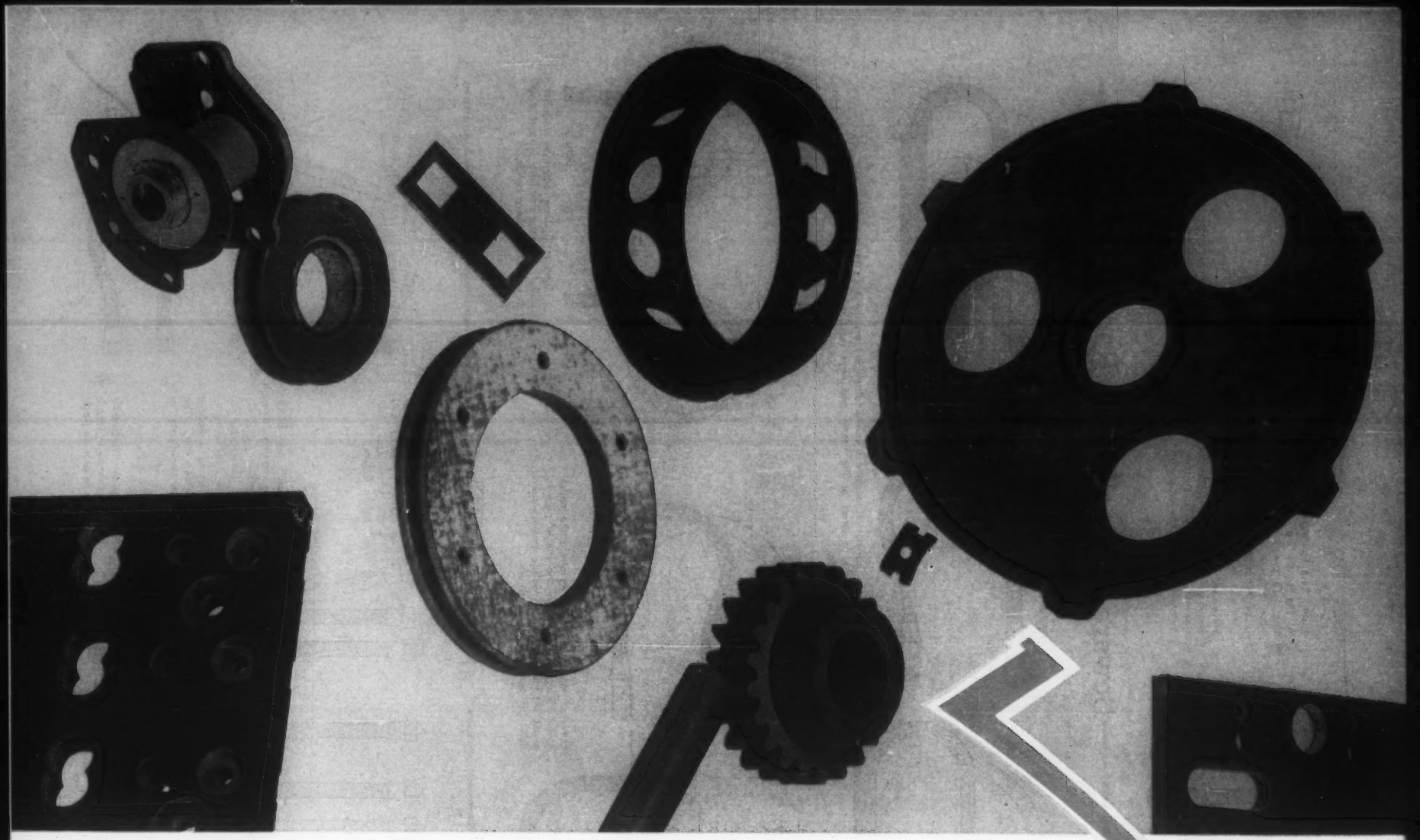




When pressure is applied to a twisted hose it tends to straighten out. The result is failure of the inner-core or loosened fittings.

Pressurization frequently causes a change in length —be sure to provide slack.





Specifying

Laminated Plastics and Vulcanized Fibers

Methods of specifying and a summary of properties in this fast-growing family of materials

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SPECIFICATION of industrial laminated plastics and vulcanized fibers may be a simple matter of matching properties to applications. However, continual and rapid growth in the varieties of these materials complicates the problem. Policies and practices in arriving at a particular selection can make the difference between a good and a poor choice. This article is a guide to specification methods.

Statements of Properties

It is advisable to determine whether published property values for a given material are typical values or minimum/maximum values. A typical value is simply a designation. A minimum or maximum value is a guarantee that the stated property will be met. Do not assume that a value listed as typical is either minimum or maximum. To minimize cost, order laminates to published standards rather than specially tailored specifications.

Common Fault I—Over-Specification

A natural hazard in specifying laminates is overspecification. For example, the dimensional stability of laminates is often thought to be inversely proportional to their water absorption, but this is not necessarily true. Where excellent water resistance is required, a laminated plastic made with a glass fabric base is often specified. Further investigation may show, however, that a less expensive paper-base laminate with a higher resin content has ample water resistance. Or it may be found that specifying slightly greater thickness will furnish sufficient water resistance without going to a more expensive material.

Another frequent overspecification is for higher electrical insulation than needed. A material may have all the desired properties for an application except that its insulation properties may be thought too low. A change in design may make the insulation value acceptable. This will often increase the reliability of the part because low insulation requirements can be met more dependably than high ones.

Copper-clad laminated plastics seem particularly subject to overspecification. Some users specify an inordinately tight bond between the laminate and the copper foil, just to play safe. The approach should be to permit lower bond strength by preventing stresses which tend to separate the foil from the laminate. For example, if an etched panel is part of a sliding electrical contact, pressing in the copper conductor to make it flush with the base laminate will prevent lifting of the conductors. Flushing has the additional advantage of minimizing arc draw and edge wear.

Sometimes, exceptionally high solder resistance—as much as 20 seconds immersion in a solder bath—is specified where 6 or 7 seconds immersion time is ample. In any case, the solderability of a copper-clad laminate is affected by the coating, and subsequent removal, of acid-resist used in making the printed circuits, so that concern with the solderability of the original copper surface is academic.

Another overspecification is the selection of laminated plastic for an application where vulcanized fiber will do as well. This is particularly true in

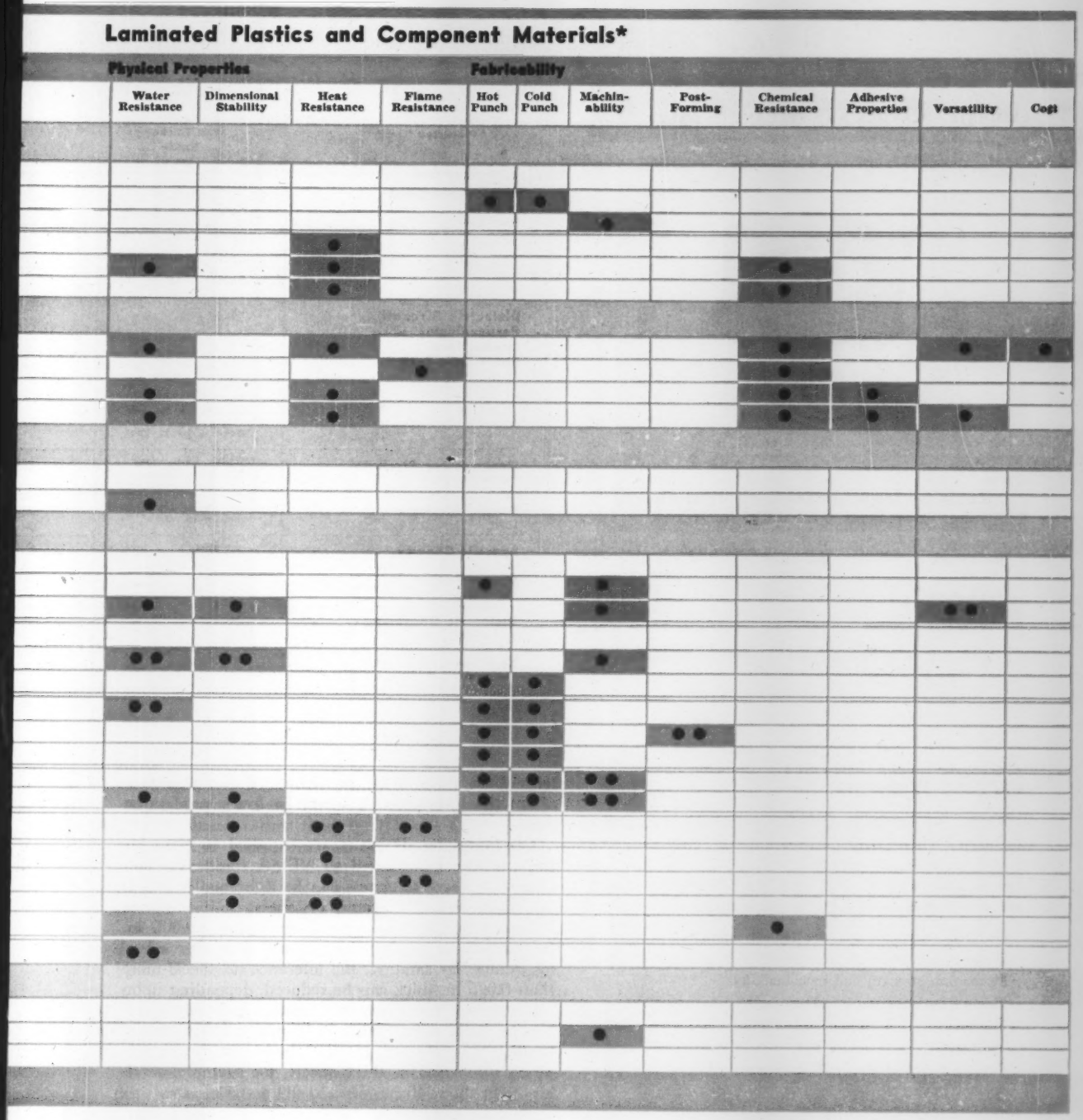
Table 1—Characteristics of Commercial

	Mechanical Properties		Electrical Properties				
	Flexural Strength	Tensile Strength	Insulation Resistance	Dielectric Strength	Dissipation Factor	Arc Resistance	
Base Material							
Paper			●	●			
Canvas	●	●					
Linen	●	●					
Asbestos							
Fibrous glass	●	●	●	●	●		
Nylon	●	●					
Resin							
Phenolics			●				
Melamines	●	●				●	
Silicones				●		●	
Epoxies	●	●					
Resin Content							
Low	●	●					
High			●	●	●		
Laminated Plastics (NEMA Grades)							
X (phenolic, paper)	● ●	● ●					
XP (phenolic, paper)							
XX (phenolic, paper)			●	●			
XXP (phenolic, paper)							
XXX (phenolic, paper)			●	●			
XXXP (phenolic, paper)			●	●			
C (phenolic, canvas)	●	●					
CF (phenolic, canvas)	●	●					
CE (phenolic, canvas)	● ●	● ●					
L (phenolic, linen)	●	●					
LE (phenolic, linen)	●	●					
AA (phenolic, asbestos)	●	●					
G-3 (phenolic, glass)	● ●	● ●	●	●	●		
G-5 (melamine, glass)	● ●	● ●	● ●	● ●	● ●	● ●	
G-7 (silicone, glass)			● ●	● ●	● ●	●	
G-10 (epoxy, glass)	●	●	●	●	●		
N-1 (phenolic, nylon)	●	●	● ●	● ●	●		
Vulcanized Fiber							
Commercial	●	●					
Bone							
Electrical			●	●	●		

*No attempt is made to rate the components or the finished materials—only to indicate the properties in which they excel.

electrical components where the hygroscopic character of vulcanized fiber has caused it to be ignored. The fact is that vulcanized fiber has excellent electrical resistance. In some applications, such as arc chutes for circuit breakers, it is even better than laminated plastic because it will not carbonize and leave carbon tracks.

Laminated Plastics and Component Materials*



Common Fault II—Under-Specification

Although less frequent than overspecification, underspecification accounts for a number of mistakes. This often results from a desire to save money on material costs. Purchase of a more expensive material may actually cut costs. An electric motor manufacturer, for example, found that he saved 18 per cent in the purchase price of laminated plastic gear blanks by changing from Grade C (canvas-base) laminate to more expensive Grade L (cotton-linen-base) phenolic. The reason: Grade C had to be sawed (flycut) into blanks, while Grade L could be punched into blanks.

Table 2—Minimum Thickness Tolerances For Sheet Stock Over 0.025 in. Thick*

Sheet Width (in.)	Tolerance (in.) One Side Sanded	Tolerance (in.) Two Sides Sanded
12 (¼ sheet)	±0.001	±0.001
24 (½ sheet)	±0.002	±0.001
48 (full sheet)	±0.003	±0.002

*These tolerances apply only to commercial grades listed in price lists and NEMA standards. Grade NS (nylon-phenolic) is not supplied with sanded surfaces.

Property	Wall Thickness Range (in.)
Water Absorption In 24 hr (per cent)	Under 1/32 to 1/32, incl.
	Under 1/8 to 1/4, incl.
	Under 1/4 to 1/2, incl.
	Under 1/2 to 1/4, incl.
	Under 1 to 1/2, incl.
Dielectric Strength Perpendicular to Laminations, Short Time Test (v per mil)	To 1/32 incl.
	Over 1/32 to 1/16, incl.
	Over 1/16 to 1/8, incl.
	Over 1/8 to 1/4, incl.
	Over 1/4 to 1/2, incl.
	Over 1/2 to 1, incl.
Compressive Strength (axially) (psi)	Wall: 1/16 in. min OD: 2 in. max
Tensile Strength (psi)	All Sizes: Up to and incl. 2 in. OD
Specific Gravity	All Sizes
Power Factor (10^6 cycles)	All Sizes
Dielectric Constant (10^6 cycles)	All Sizes
Loss Factor (10^6 cycles)	All Sizes

Opposing Properties

Overspecification and underspecification can occur together when overspecification of one property causes sacrifice of another. Table 1 can help to reveal and resolve these conflicts. Properties which are sometimes at odds with each other are:

Dielectric strength and mechanical strength.

Dimensional stability and electrical insulation.

Mechanical strength and machinability.

Flame retardance and impact strength.

Flushability and distortion-resistance (in copper-clad laminates).

Punchability and electrical resistance.

Commercial Stock Forms

Specification of form is often based on the assumption that, logically, flat pieces should be fabricated from sheet stock, rod-like parts from rods, and tubular parts from tubing. This is not always true. A manufacturer of television parts, for example, found that a tuner shaft with two flat sides could be fabricated more economically from sheet instead of rod.

Laminated sheets can be ordered at standard thicknesses, listed by the manufacturer, or at intermediate thicknesses. Sometimes the higher cost of intermediate sheets is offset by lower production costs.

Laminates in all forms are supplied to commercial tolerances published as NEMA standards. Tolerance on sheet thickness can be tightened by sanding. Commercial tolerance on sheets 1/16-in. thick is determined by the type of material—±0.005 in. for paper-base grades; up to ±0.018 in. for asbestos grades. By sanding, the tolerance on sheets more than 0.025-in. thick can be reduced, depending upon the width of the sheet and whether it is sanded on one or both sides, Table 2. The additional cost of sanding is governed by the thickness of the material. On 0.020-in. thick sheets, for example, sanding adds about 40 per cent to the material costs.

Tubing Forms and Sizes

Laminated plastic tubing comes in two forms: Rolled and molded. Both are made the same way except that molded tubing is finish-cured in a mold under pressure, thus compressing the tube wall and making a denser material. Properties of tubing are shown in Table 3. Differences between the two types are shown in Table 4. In general, rolled tubing has better electrical properties and better concentricity, while molded tubing excels in mechani-

Table 3—Average Properties of Rolled and Molded Tubing

Paper Base Phenolic					Fabric Base Phenolic				Fabric Melamine		Cotton Fabric Phenolic		Melamine Glass Cloth		Asbestos Mat Phenolic
Grade X	Grade XX, XX-9		Grade XXX		Grade C, CE, CEF, C9		Grade CE-6		Grade C-5, L-5		Grade L, LE		Grade G-5		Grade AAA
Rolled	Rolled	Molded	Rolled	Molded	Rolled	Molded	Rolled	Molded	Rolled	Molded	Rolled	Molded	Rolled	Molded	Rolled
5.5	4.5	3.2	3.6	3.0							7.5	4.2			
3.3	2.6	1.7	2.4	1.5	5.0	2.5	2.0	1.5	7.0	4.5	3.2	2.4	3.5	3.0	2.6
1.9	1.6	1.2	1.4	1.1	3.0	1.8	1.3	1.0	4.5	3.5	1.8	1.6	2.8	2.0	2.0
1.7	1.4	0.80	1.2	0.70	2.4	1.4	1.0	0.80	3.0	2.3	1.5	1.3	2.4	1.6	1.5
1.5	1.2	0.70	1.0	0.65	1.8	1.1	0.80	0.60	2.5	1.8	1.2	1.0	1.8	1.3	1.3
750	750		750								100	175	120	100	
600	600	425	600	400	85	250	185	275	70	225	150	300	130	135	300
450	450	300	450	300	100	175	275	300	90	175	200	225	100	160	260
350	350	210	350	210	90	120	210	220	75	120	120	150	85	125	180
225	225	140	225	140	75	85	150	160	60	85	85	100			120
150	150	100	150	100	65	70	100	100	50	70	70	80			90
14,000	15,000	18,000	15,000	18,000	18,500	22,000	19,000	23,000	16,000	22,000	19,000	23,000	22,000	24,000	11,000
9,000	8,500	9,500	8,000	9,000	7,500	8,000	8,500	9,000	6,000	8,000	7,500	8,000	20,000	21,000	6,000
1.15	1.15	1.30	1.15	1.28	1.15	1.30	1.20	1.28	1.15	1.35	1.15	1.30	1.60	1.80	1.34
0.030	0.027	0.035	0.027	0.035	0.060	0.080	0.040	0.050			0.060	0.080	0.013	0.020	
4.5	4.2	5.2	4.2	5.2	5.5	6.0	5.2	5.2			5.5	6.0	6.5	7.0	
0.13	0.11	0.18	0.11	0.18	0.33	0.48	0.21	0.27			0.33	0.48	0.08	0.14	

cal properties, bond strength, and water resistance.

It is usually best to specify tubing by ID and wall thickness rather than by ID and OD, or OD and wall. If minimum wall thickness is important, it costs less to specify a slightly heavier wall rather than a closer wall tolerance. With heavier walls, too, the tubing is more likely to remain round.

For tubular parts in miniature equipment, designers can specify laminated plastic tubing below $\frac{1}{8}$ in. ID, Table 5.

Fabricated Parts

When ordering parts made from laminated plastics and vulcanized fiber, a common mistake is specifying tighter tolerances than needed. One reason is that tolerances for metal parts are carried over to the more pliable laminates. A good tolerance for laminate parts is ±0.005 in.; ±0.003 in. is close; ±0.001 in. creates problems.

Drilling and reaming holes permits closer tolerances than punching, but punching costs less. Some factors that determine practicable punching tolerances are: Grade and thickness of material, size of holes, over-all size of the part, change in moisture content after punching, and change in temperature of the part if it is hot punched. Tolerances

Table 4—Areas of Applications Of Laminated Tubing

	Rolled Tubing	Molded Tubing
Water absorption		●
Dielectric strength	●	
Power factor	●	
Dielectric constant	●	
Compressive strength, axially		●
Tensile strength		●
Concentricity	●	
Bond strength with bulky web materials		●

Table 5—Sizes of Small ID Rolled Laminated Tubes*

Inner Diameter (in.)	Wall Thickness (in.) Min	Max	Approx Length (in.)
0.050			10
0.060	0.015	1/32	10
0.070	0.015	1/32	10
0.080	0.015	3/64	10
0.090	0.015	3/64	24
0.100	0.015	3/64	24
0.110	0.015	1/16	24
0.125	0.015	1/16	24 and 36

*Dimensions are those of Taylor Fibre Co.

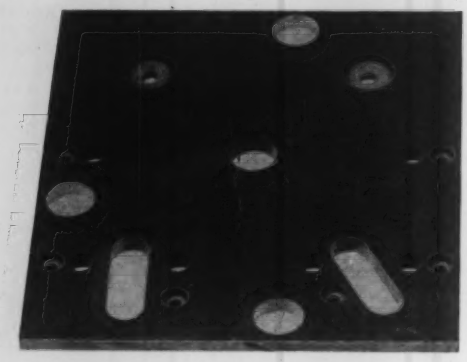


Table 6—Tolerance Ranges for Punched Holes

Material	Material Thickness	Hole Sizes (in.) Up to ¼	¼ to ½	½ to 1	1 to 3
Vulcanized Fiber:					
	1/32	0.006	0.006	0.008	0.012
	1/16	0.006	0.006	0.008	0.012
	1/8	0.007	0.008	0.010	0.015
	1/4	0.009	0.012	0.014	0.020
Laminated Plastics:					
XP	1/32	0.004	0.004	0.005	0.008
	1/16	0.006	0.006	0.006	0.010
	1/8	0.008	0.008	0.008	0.012
XXP	1/32	0.005	0.007	0.007	0.010
	1/16	0.006	0.008	0.008	0.012
	1/8	0.008	0.010	0.010	0.015
XXXP	1/32	0.005	0.007	0.008	0.010
	1/16	0.006	0.008	0.008	0.012
	1/8	0.008	0.010	0.010	0.015
L	1/32	0.004	0.005	0.006	0.010
	1/16	0.005	0.006	0.007	0.010
	1/8	0.008	0.010	0.012	0.012
C	1/32	0.005	0.006	0.008	0.010
	1/16	0.006	0.008	0.010	0.010
	1/8	0.008	0.010	0.012	0.012

for punched are listed in Table 6.

In good punched-parts design the space between adjacent edges of holes or between the edge of a hole and the edge of the piece should be equal to 1½ times the thickness of the material. At no time should this space be less than the thickness of the material.

No-Cost Extras

Laminated plastics offer certain "extras" at no additional cost. An example is color facing on paper-base laminates. There are many reasons why it is desirable to tell which side is which. Some are:

- To identify the source of supply.
- To facilitate assembly of parts which seem symmetrical but actually are not.
- To identify material or parts of different thicknesses.
- To identify parts of the same general appearance but of slightly different size.
- To identify parts according to their end use.

Color identification need not be limited to facing. In bars and rods, or in thick sheets, some of the base material inside the laminate may be colored.

Another no-cost extra occurs in postforming grades of laminates. These laminates have specially processed resin and a base material, either paper or fabric, with more stretch than the usual fabric. Postforming laminates can be formed into intricate shapes, compound curves, and deep draws.

Composite Laminates

Recent advances in bonding techniques have made it possible to bond virtually any compatible material with a laminate. Best known of the composite laminates is copper-clad laminated plastic, a standard material for the etching of printed circuits. Some other composite laminated plastics, usually manufactured to customer specifications, are:

- Vulcanized fiber-clad laminates. These types combine the high strength of laminated plastics with the superior hot-arc resistance of vulcanized fiber, as in switch gear for both low and high voltage.
- Rubber-clad laminates. Almost any type of natural or synthetic rubber, including Buna N and Buna S, may be used as the cladding material. They are useful where sealing or chemical resistance is needed and for isolating vibration.
- Asbestos-clad laminates. Laminated plastic clad with untreated asbestos paper has high heat resistance and arc resistance.
- Laminate-clad lead. Lead sheets bonded between paper-base laminates have been used for x-ray shields.
- Aluminum-clad laminate. Laminated plastics with aluminum cladding have been used extensively for engraving stock. The laminate base is black in color, providing a good contrast with the aluminum when the design is etched away.
- Beryllium copper-clad laminates. Beryllium copper is non-magnetic and a good conductor. The composite material has possibilities in printed circuits.
- Stainless steel-clad laminates. This material has application where nonmagnetic properties are required. Other applications are in corrosive environments.
- Magnesium-clad laminates. Sheets as long as 108-in. have been made into screens for x-ray operators.
- Silver and gold-faced laminates. High electrical conductivity of silver and gold indicates possible use of the composite materials for electrical contacts. The laminate provides strength and insulation.

Metal cladding can be bonded to almost any grade of laminated plastic. It is usually necessary to treat the metal to eliminate oxides.

A variety of materials can also be bonded to vulcanized fiber. One of the most common is natural and synthetic rubber for gasket applications. The composite material has excellent strength and good sealing properties and chemical resistance. Aluminum-clad fiber has been used as shielding inside automobile horns and has been investigated as a possible material for condensers.

Combination laminates and vulcanized fiber can be specified in sheets, rods, or tubes. Sizes are the same as for the base material.

A simple, direct procedure for finding dimensions of

Minimum-Weight Tubular Members

under torsion and internal pressure

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DESIGN of tubular members of minimum weight often requires analysis of the effect of combined stresses. Conventional approach is to use a trial-and-error procedure until the required margin of safety is obtained.

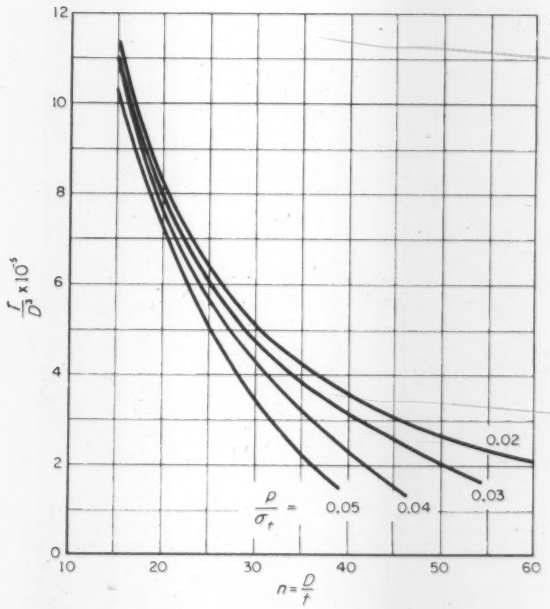


Fig. 1—Limit conditions for safe design of alloy-steel tubular members under torsion and internal pressure. Plots represent solutions of Equation 4 for σ_t = 180,000 psi.

This article presents a simplified method for direct determination of the dimensions of minimum-weight round tubes which are subjected to internal pressure and torsion. The analysis presented here is based on the circular interaction relationship developed by Sadowsky.[1] Although only alloy-steel tubes are considered, the method has general applicability and can readily be extended to steels of other strength levels, as well as to aluminum and magnesium alloys.

Basic Relationships: For tubes in which stresses are a result of the combined effects of torsion and internal pressure, a criterion for safe design can be developed in terms of the stress ratios, R_p and R_{st} (see Nomenclature). As shown in Reference 1, the tubular member will be safe if the sum of the squares of the stress ratios is equal to or less than unity. For the limit condition, then,

$$R_{st}^2 + R_p^2 = \left(\frac{\sigma_{sta}}{\sigma_{st}}\right)^2 + \left(\frac{\sigma_h}{\sigma_t}\right)^2 = 1 \qquad (1)$$

Substituting the classic expressions for torsion and hoop-tension stresses into this equation,

$$\left(\frac{TD}{4I\sigma_{st}}\right)^2 + \left(\frac{pD}{2t\sigma_t}\right)^2 = 1 \qquad (2)$$

Moment of inertia of the tubular section is

$$I = \frac{\pi D^3 t}{8} = kD^3 t \qquad (3)$$

[1]References are tabulated at end of article.

Combining Equations 1, 2, and 3, rearranging terms, and simplifying gives

$$\left(\frac{T}{D^3}\right)^2 = \frac{16k^2\sigma_{st}^2}{n^2}\left(1 - \frac{p^2n^2}{4\sigma_t^2}\right) \quad (4)$$

where

$$n = \frac{D}{t} \quad (5)$$

Value of n is assumed to be sufficiently large so that simplified expressions for I and A are applicable.

Graphical solution of this equation is given in Fig. 1 for an alloy steel with σ_t = 180,000 psi. These plots are based on strength data given in Reference 2.

Equation 4 is based on the assumption of zero margin of safety. For combined stresses of the type considered here, the margin of safety is defined by

$$\frac{1}{\sqrt{R_{st}^2 + R_p^2}} - 1 = M \quad (6)$$

or, in modified form,

$$R_{st}^2 + R_p^2 = \left(\frac{1}{1+M}\right)^2 = U^2 \quad (7)$$

On the basis of Equation 7, Equation 4 can now be modified to include any desired margin of safety for tube-size calculations. Starting with Equation 7 and following the same procedure which led to Equation 4,

$$\left(\frac{T}{D^3}\right)^2 = \frac{16k^2\sigma_{st}^2}{n^2}\left(U^2 - \frac{p^2n^2}{4\sigma_t^2}\right) \quad (8)$$

Optimum Design: Expressed in terms of tube-section area, Equation 4 becomes

$$\frac{T^2}{A^3} = \frac{n^3}{\pi^3}\left(\frac{16k^2\sigma_{st}^2}{n^2}\right)\left(1 - \frac{p^2n^2}{4\sigma_t^2}\right) \quad (9)$$

Inverting this equation and taking the cube root,

$$\frac{A}{T^{2/3}} = \frac{2.33}{n^{1/3}\sigma_{st}^{2/3}}\left(1 - \frac{p^2n^2}{4\sigma_t^2}\right)^{-1/3} \quad (10)$$

Graphical solution of this equation is plotted in Fig. 2 for alloy steel tubes with σ_t = 180,000 psi. The lowest point on these curve plots corresponds to the tube of least section area and, hence, weight for a given value of p/σ_t. Thus, these plots represent optimum design curves for tubes of the given material. They were developed by the following procedure:

1. Assume a value for n and for ratio p/σ_t.
2. Find σ_{st} corresponding to n, from Fig. 3.
3. Calculate $A/T^{2/3}$ from Equation 10.

This same procedure can be used to develop design curves for tubes of any other material where σ_{st} is known.

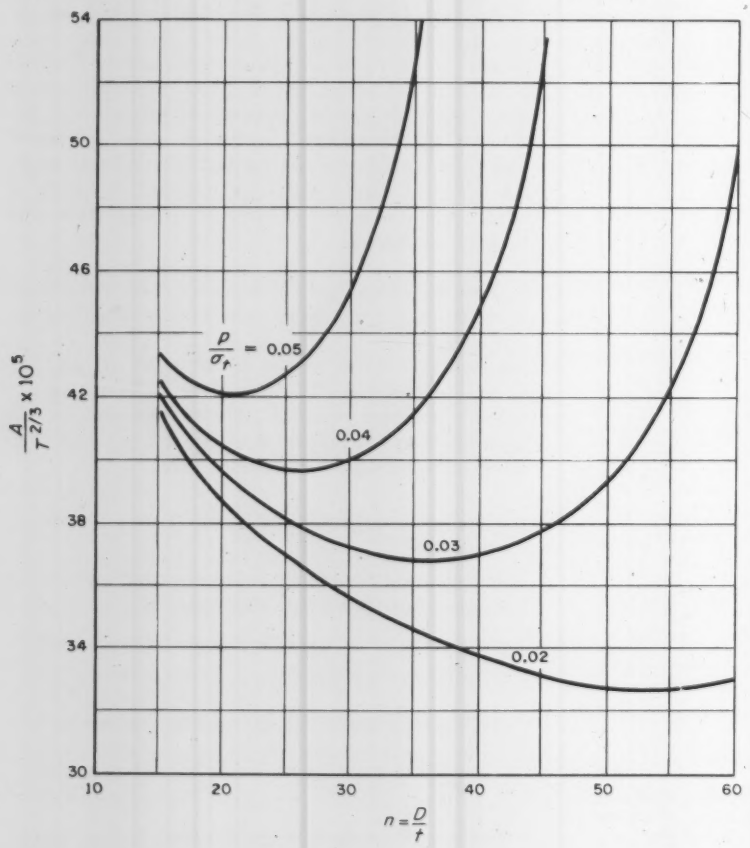


Fig. 2—Optimum design curves for alloy-steel tubular members. Low point on each curve corresponds to minimum-weight tube section for the given value of p/σ_t. Plots represent solutions of Equation 10 for σ_t = 180,000 psi.

Thus, if internal pressure p and applied torque T are known, diameter and wall thickness for an alloy steel tube of minimum weight can be found directly from Fig. 2. However, one relationship should be kept in mind. In Equation 10, note that for any arbitrary value of T, A becomes indefinitely large as $pn/(2\sigma_t)$ approaches one.

Equation 10, like Equation 4, can be modified to incorporate a suitable margin of safety. Thus,

$$\frac{A}{T^{2/3}} = \frac{2.33}{n^{1/2}\sigma_{st}^{2/3}} \left(U^2 - \frac{p^2 n^2}{4\sigma_t^2} \right)^{-1/3} \qquad (11)$$

As shown in Fig. 2, the optimum value of $n = D/t$ decreases as p/σ_t increases. These optimum values can also be determined in another way:

1. Write the expression for modulus of rupture σ_{st} as a function of $n = D/t$.
2. Substitute this expression in to Equation 10.
3. Find differential, $dA/d(n)$, for resulting equation.
4. Set $dA/d(n)$ equal to zero and solve for $n = (D/t)_{opt}$.

This method involves the solution of an algebraic equation of the fourth degree in n, or D/t. Numerical methods can readily be programmed for machine computation.

Nomenclature

A = Tube-section area, sq in.
D = Outside diameter of tube, in.
I = Moment of inertia of tube section, in.^{4}
k = Constant
M = Margin of safety
p = Internal pressure, psi
R_p = Hoop tension stress ratio $= \sigma_h/\sigma_t$
R_{st} = Torsion stress ratio $= \sigma_{sta}/\sigma_{st}$
T = Applied torque, lb-in.
t = Wall thickness, in.
σ_h = Hoop-tension stress, psi
σ_{st} = Torsional modulus of rupture (allowable torsional shear stress) for tube material, psi
σ_{sta} = Torsional shear stress developed by applied torque, psi
σ_t = Allowable tensile stress for tube material, psi

Design Example: The upper section of the cylinder tube in an aircraft oleo-pneumatic shock absorber is subjected to an internal pressure of 5500 psi from the air chamber. Under certain conditions of operation, a maximum torque of 750,000 lb-in. is developed in this tube section. If the cylinder tube is to be made of alloy steel with $\sigma_t = 180{,}000$ psi determine the dimensions of the tube section for minimum weight.

For the given data, $p/\sigma_t = 5500/180{,}000 = 0.0304$. From Fig. 2, $n = (D/t)_{opt} = 37.5$ (approx.) and $A/T^{2/3} = 36.8 \times 10^{-5}$. Thus,

$$A = \pi D t = 36.8(10^{-5})T^{2/3} = 36.8(10^{-5})(750{,}000)^{2/3}$$

$$= 3.03 \text{ sq. in.}$$

Modifying the form of the area expression,

$$A = \pi D \left(\frac{D}{37.5} \right) = \frac{\pi D^2}{37.5}$$

Solving for D,

$$D = \sqrt{\frac{37.5(3.03)}{\pi}} = 6.01 \text{ in.}$$

Then,

$$t = \frac{D}{\frac{D}{t}} = \frac{6.01}{37.5} 0.16 \text{ in.}$$

This solution can be quickly checked with Equation 2. From Fig. 3, $\sigma_{st} = 0.552\ (180{,}000) = 100{,}000$ psi. The left-hand side of Equation 2 can now be evaluated, using the calculated values of D and t, to verify the accuracy of the solution.

Assume a value of $n = D/t = 50$ is used for design of the tube. From Fig. 2, $A/T^{2/3} = 39 \times 10^{-5}$. The increase in weight for this tube section as compared to the previous example is (100) (39-36.8)/(36.8) = 6 per cent.

References

1. M. A. Sadowsky—"A Principle of Maximum Plastic Resistance," *ASME Transactions*, June, 1943, p. A65.
2. "Strength of Metal Aircraft Elements," ANC-5 Bulletin, March, 1955, p. 48, Fig. 2.42b.

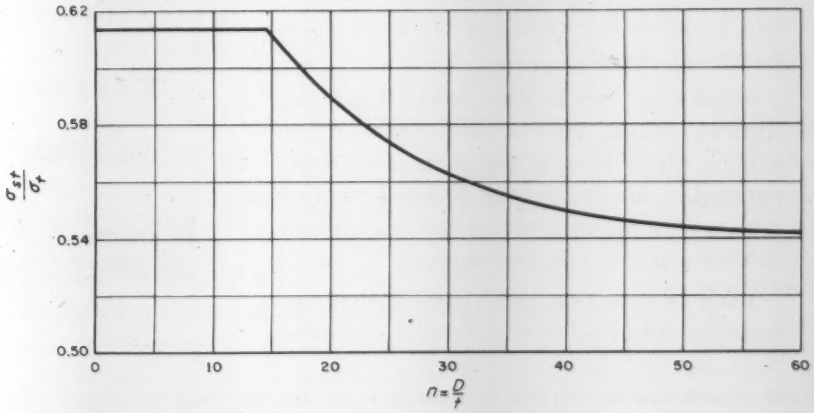
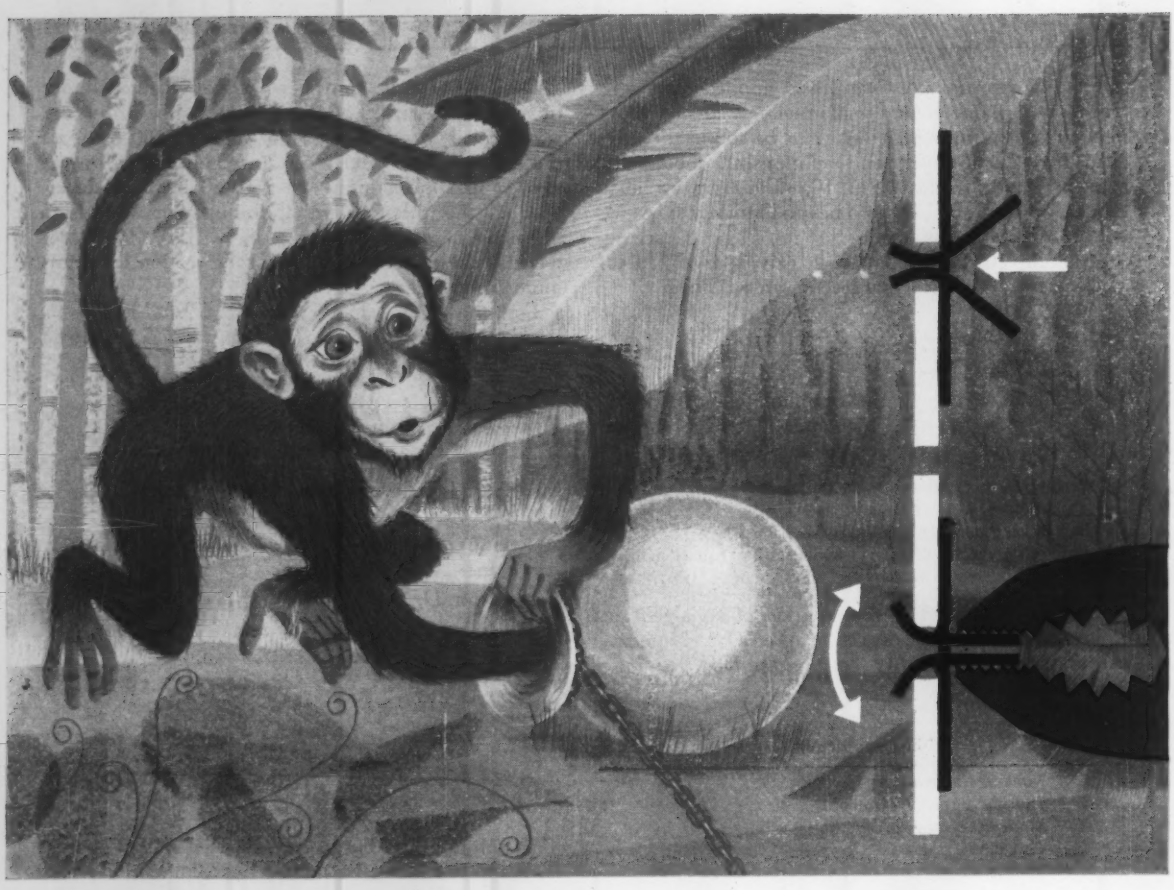


Fig. 3—Effect of tube proportions on torsional modulus of rupture for alloy-steel tubular members when allowable σ_t = 180,000 psi.



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Engineering Organization

Form and functions must follow changing and varied assignments.

CHARLES E. PAULES
Vice-President, Engineering
Esso Research and Engineering Co.
Linden, N. J.

CONTINUAL change, review, and revision are the facts of life in most walks of life. They apply especially to engineering organizations where continual improvement of the product creates an atmosphere favorable to critical self-examination. Activities within engineering departments must be functional in the same way that engineering itself is functional within companies. Monitoring these activities is the job of engineering management. This article indicates the scope of that field.

Engineering Organization. It has become popular in recent years to speak of the "rule of 5" which says that, in general, each supervisor should have five men reporting to him. This would indicate that a department might be set up on the basis of 150 to 160 men arranged thus:

Director
Associate Director
5 Assistant Directors
25 Section Heads
125 Engineers

While the effect of numbers of employees cannot be overlooked, there is a second, perhaps more important, factor to be considered. This is the diversity of operations.

An organization which reflects this consideration is shown by Fig. 1 *left*. It introduces one additional level—the group head. Divisions run from 200 to 350 persons but each involves a wide spread of technical fields.

A section head is usually responsible for one field of technical activity. The number of men in a sec-

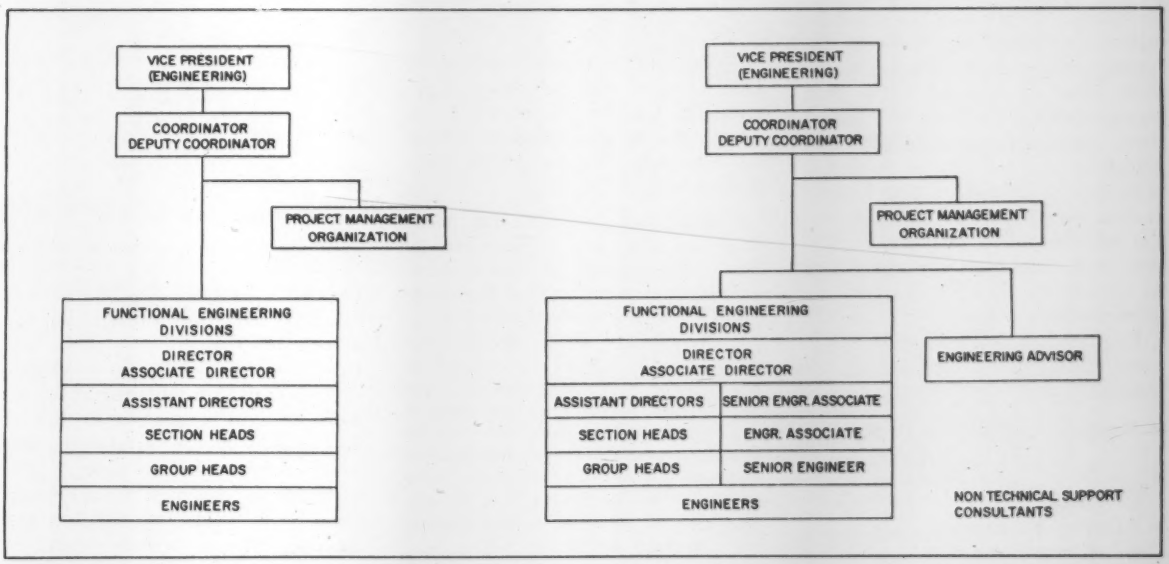

Fig. 1—Left—Arrangement and levels of management in a single engineering organization intended to perform relatively limited functions. Right—An organization which has parallel "ladders" for supervisory and nonsupervisory personnel.

tion runs from about 20 to 40 although the number may be higher. This is the first level which begins to carry real administrative responsibility. These men are primarily responsible for the planning and scheduling of work in their own portion of the organization, for employee ratings, salary recommendations, and the general run of administrative problems.

The director and associate are responsible for the over-all operation of the division. Whether or not an associate is required depends upon the nature of the division's operation.

The organization for any engineering department must be tailored to the requirements which it must fulfill. It cannot be static. Maintenance of an adequate organization must be based on both long-range and short-range plans. On the basis of long-range study, an optimum organization can be visualized without consideration to the present organization.

With a long-range optimum organization in mind, continuing study should be given to the need for change as a result of new products, new processing methods, and improvement in plant facilities.

No matter how well a department may be organized, its successful functioning depends on the capabilities of everyone in the department. This is especially true of supervisory personnel. To promote the development of technical expertness in the nonsupervisory field, it is necessary that those so engaged know that management is willing to accord them adequate compensation and recognition. One way to do this is with a technical ladder, Fig. 1 *right*. It has rungs parallel to those in the administrative progression ladder, with titles that are recognized as equivalent to the corresponding administrative titles.

Engineering Administration: Responsibilities of engineering administration cover:

- Maintaining adequate working conditions.
- Contact with other departments of the company.
- Budgeting of department cost and control of its operating costs.
- Seeking ways of doing things to reduce capital investment and operating costs.
- Work scheduling.
- An awareness of new techniques or engineering tools which might be used to improve department efficiency.
- Keeping abreast of developments in the field through technical society participation and literature.
- Personnel evaluation and development of replacements.

The best engineering work is done by a department which has a high sense of cost consciousness. An annual budget of both personnel and money, operating and capital, should be prepared by the engineering department. By controlling its own costs, the department develops cost consciousness elsewhere.

High quality cost estimates, whether for new work or modifications, are of vital importance. While some things must be done to maintain operations, in many cases the decision to go ahead is based on economics. Poor estimating leads to faulty economic pictures and can kill good projects.

Careful scheduling aids both long and short-range planning. Schedules give advance knowledge as to when expansion of personnel may be needed or when a reduction should be considered.

Standards of one sort or another should be used to the fullest extent possible. Engineering standards, design practices, standard purchase specifications, are quite common. When the nature of the work permits, it is often possible to supplement these with standards of a more technical nature.

Keeping abreast of new techniques or engineering tools, is essential in maintaining maximum efficiency. There is an ever-increasing use of higher mathematics, high-speed computers, and operations research. If they fit plans and budgets, use them. An organization which does not have the volume to warrant this, can still utilize these techniques by the use of consultants.

Information made available by technical societies and technical literature will help in maintaining and steadily improving efficiency. Participation in society activities is part of an engineer's responsibility, a source of satisfaction to him, and a source of benefit to his employer.

ASME Paper No. 59-A-245, *"Modernized Engineering Organizations," presented at the Annual Meeting, Atlantic City, N. J., November-December,* 1959, 7 *pp.*

materials

Asbestos-Reinforced Laminates At High Temperatures

Norman E. Wahl
Cornell Aeronautical Laboratory

Development and test of a high-strength, low-density material for use in the range of 500 to 1000 F for relatively long periods of time. Results were:

1. When long-fibered chrysotile-asbestos fibers are used as a reinforcement for heat-resistant phenolic or silicone resins, the composite must be molded at pressures above 200 psi for optimum properties.

2. Phenolic and silicone-asbestos specimens exposed to high temperature, erosion, and variation in the percentage of oxygen fared rather badly. The percentage of oxygen had no appreciable effect on the rate of degradation. The phenolic asbestos specimens showed considerably lower weight loss due to erosion than the silicone asbestos. However, neither material was considered satisfactory.

3. Based upon depth of penetration of ablation and the amount of material ablated away, phenolic asbestos was considerably more resistant than silicone asbestos.

4. Silicone asbestos laminates maintained a high percentage of their mechanical properties up to 800 F.

SAE Paper No. 106V, *"Properties of Asbestos Reinforced Laminates at Elevated Temperatures," presented at the SAE National Aeronautical Meeting, Los Angeles, October,* 1959, 9 *pp.*

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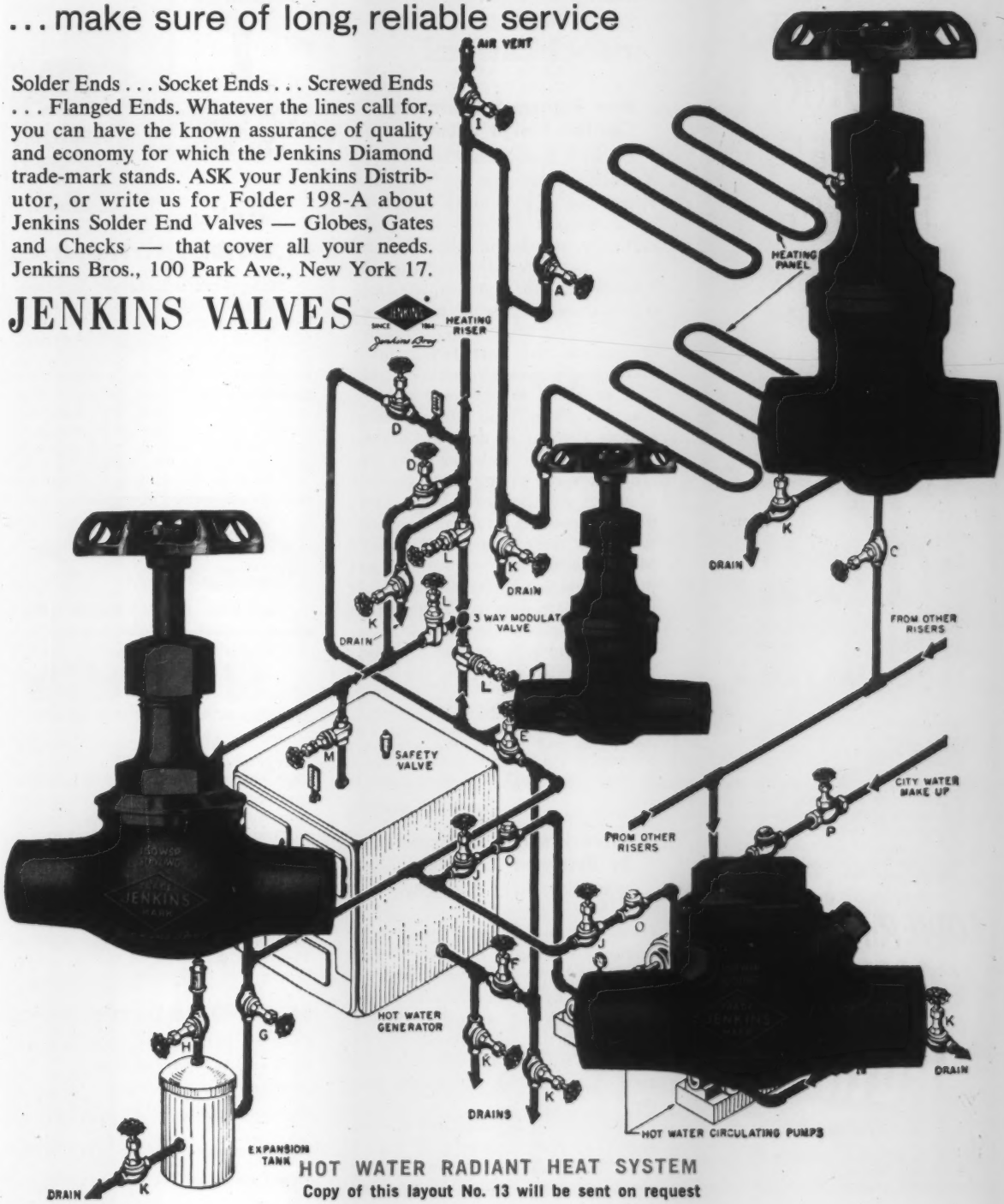

HOT WATER RADIANT HEAT SYSTEM

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spot-weldable material and eliminates the problems involved in developing new brazing techniques. Sample products and some design problems are discussed.

SAE Paper No. 99T, presented at the SAE National Aeronautical Meeting, Los Angeles, October, 1959, 7 pp.

mechanical

How Positional Tolerancing Clarifies Design Intent

Edward S. Roth, Sandia Corp.

A basic explanation of positional tolerancing (PT) and the maximum metal concept (MMC) which are currently displacing the bilateral system. Examples are proof that the bilateral system is incomplete, ambiguous, and impossible to gage accurately. The bilateral system merely outlines the part requirements and actually allows inspection to accept or reject to arbitrary criteria. The disturbing result: As inspection criteria change, so does the design.

If companies with far-flung operations want to use their product drawings as the control specification, the positional tolerancing technology is their solution. The PT/MMC technology uniformly expresses and interprets tolerances. It is a complete dimensioning tool in the hands of the designer and enables him to fully express and control his design intent on the product drawing.

ASTE Paper No. 225, Vol. 59, Book 2, "How Positional Tolerancing Clarifies Design Intent and Reduces Product Cost," presented at the 27th Semiannual Meeting, St. Louis, October, 1959, 12 pp.

Curve Families Extrapolated By Recurrent Relations

A. Mendelson and S. S. Manson, NASA, Cleveland, Ohio.

Using finite-difference recurrence relations for direct extrapolation of families of curves. The method is illustrated by applications to creep-rupture data for several materials. It is shown that good results can be obtained without the necessity for any of the usual parameter concepts.

The method is based on the assumption that a family of curves can be represented approximately by a finite-difference recurrence re-

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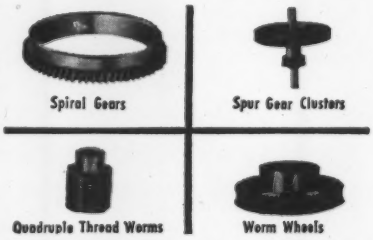

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lation. Once the coefficients of this recurrence relation are determined, it is a simple matter to extrapolate each member of the family individually.

The method has the advantage that it does not require an explicit knowledge or assumption as to the analytical character of the curves or as to what parametric form to use to correlate the data.

ASME Paper No. 59-A-155, "The Extrapolation of Families of Curves by Recurrence Relations, With Application to Creep-Rupture Data," presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 8 pp.

processes

Effects of Hydrogen Brazing On High-Temperature Alloys

G. S. Hoppin III and E. N. Bamgerger, General Electric Co.

The extent of changes in base-metal strength resulting from brazing temperatures. Eight alloys currently used for fabricated high-temperature jet-engine components were subjected to brazing thermal cycles, and subsequently tested for tensile and stress-rupture properties. In these cycles, the subject materials were exposed for 1 hr at temperatures above 2000 F with a maximum temperature of 2240 F.

It was noted that, generally, the weakest high-temperature alloys incurred the greatest strength losses, which in most cases were irrecoverable. Conversely, the strongest alloys exhibited the least loss of properties and, in most instances, responded to post-brazing heat treatments.

AWS paper presented at the 40th Annual Meeting, Chicago, April, 1959, 8 pages.

Magnetic Tape Characteristics And the Recording Process

J. G. Woodward and E. Della Torre, RCA Laboratories, Princeton, N. J.

A new approach toward gaining an analytical understanding of the recording process. The process and the magnetic characteristics of the recording medium are described in terms of a three-dimensional distribution function whose co-ordinates are the positive and the negative switching fields and the magnetic

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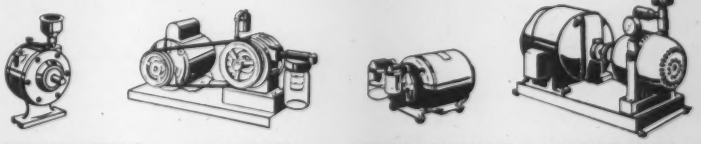

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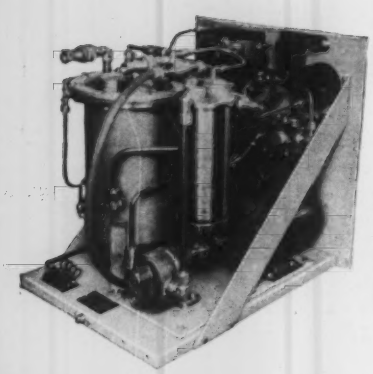
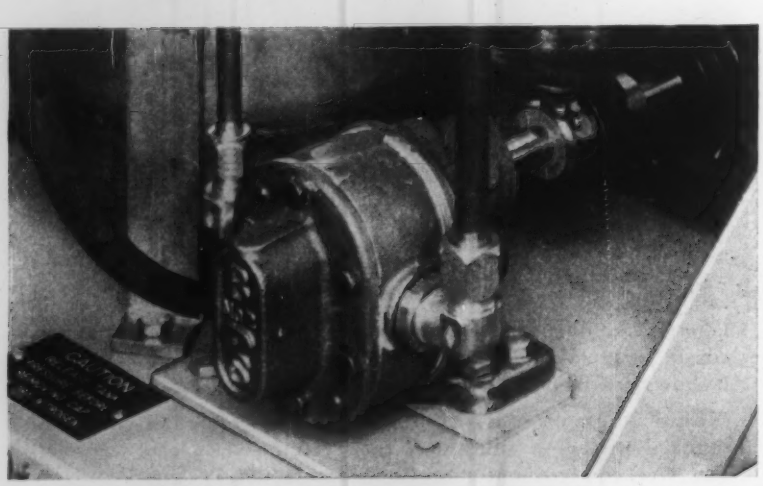


Unit for cooling electron tubes in radar environmental test equipment — one of many products developed and manufactured by Industrial Control Products, Inc., Caldwell, N. J.

Why Industrial Control Products designers choose Brown & Sharpe pumps to circulate new coolant



Problem: Designers of this unit for cooling electron tubes needed pumps capable of handling an extraordinarily efficient new dielectric coolant: FC75. To prevent contamination, no ferrous metals could touch the fluid. 4 gpm delivery at 150 psi pressures must be maintained at temperatures from minus 60C to +100C. None of many standard and special pumps first tried was satisfactory.

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moments of the individual particles of the tape coating. Means for measuring the distribution function are described and examples are shown. Using the measured distribution function, the small-signal recorded magnetization as a function of frequency is calculated for some simple cases of high-frequency-bias recording.

AES Paper No. 116, "Magnetic Characteristics of Recording Tapes and the Mechanism of the Recording Process," presented at the 11th Annual Meeting, New York, October 1959, 11 pp.

techniques

Total Concept of Numerical Control

William B. Johnson, Industrial Engineer, Rocketdyne Div. of North American Aviation

An integrated program from the original design intent or concept through the finished part and final inspection, utilizing numerical control as a tool through all phases. Successive steps are:

1. In preliminary and advanced design stages, many possible rocket-engine design parameters are compared and evaluated to obtain optimum performance designs by extensive computer programs.

2. Complete mathematical - analytical definitions to express the engineering-design intent are obtained by computer programs where necessary.

3. These definitions are utilized to produce engineering test programs by numerical control to check out preliminary designs before the manufacturing phase. The test phase involves two and three-dimensional models for photoelastic stress analyses.

4. Engineering drawings are made directly into the language of numerical control.

5. Adjunct tooling is produced, using the original engineering definitions, by automatic computer programs and automatic programmed tooling.

6. Parts are manufactured either directly by numerical control or by tooling produced through numerical control during the manufacturing phase.

7. The parts are checked during manufacture, using inspection optical comparators, or master-milled inspection templates, which were produced by numerical control.

8. Checking of parts by inspection and quality control departments is done on a numerically controlled measuring machine with print-out data, or by another

numerically-controlled machine with an inspection part path tape instead of the center-line cutter location tape to compare and analyze finished parts to the original design intent.

ASTE Paper No. 217, Vol. 59, Book 2, presented at the 27th Semiannual Meeting, St. Louis, October, 1959, 16 pp.

Determination of Local Heat-Transfer Coefficients

R. A. Stanley and J. B. Conway, General Electric Co.

Description of a transient technique used to determine local heat-transfer coefficients for a tube, two parallel flat plates, and two parallel corrugated plates. Coefficients are determined for bulk-air temperature of 70, 300, and 500 F in the Reynolds Number range of 20,000 to 70,000. The technique represents a very simple and accurate method for determining local heat-transfer coefficients for certain specimens. Values obtained for tubes are in excellent agreement with the steady-state values reported in the literature. Values for corrugated surfaces vary with amplitude of the surface wave and are about twice the values obtained for parallel flat plates. The method described offers a means of studying heat-transfer characteristics of certain geometries which are difficult to heat under steady-state conditions.

Paper V-40, Nuclear Engineering and Science Conference, Cleveland, 1959; 12 pp.

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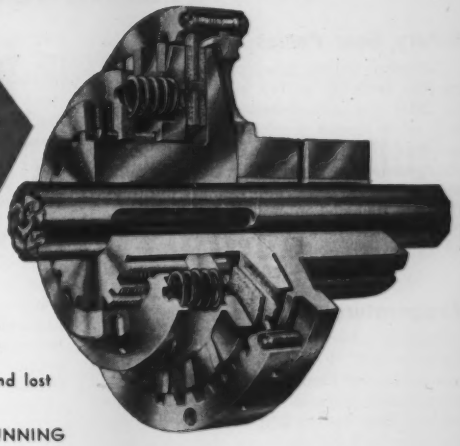

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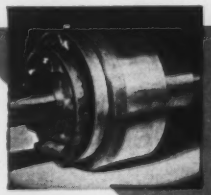

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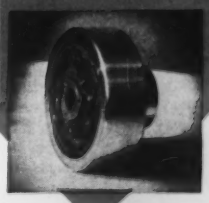

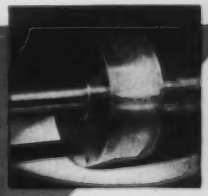

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Circle 601 on Page 19

Temperature Controls

Surface mounting temperature controls for 0 to 300° F and 0 to 600° F ranges are subject of Data Sheet MC-186. These snap-action bimetal units are adjustable within their ranges and are rated 1200 w at 120 v ac. Dimensioned drawings simplify design and application engineering. 2 pages. Fenwal Inc., Pleasant St., Ashland, Mass. B

Circle 602 on Page 19

Alloy Resistor Wire

Low density, high resistivity Alloy 815-R precision resistor wire in diameters ranging from 0.0031 to 0.005 in. is covered thoroughly in illustrated catalog. It is rated 815 ohms per cmf at 20° C. Fabricating, handling, and engineering data are included. 12 pages. Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich. T

Circle 603 on Page 19

Instrument Facilities

Details of machinery and testing equipment, engineering and research capabilities, and typical products made to customer specifications in the field of panel instruments, protective relays, switchboard instruments, rotary switches, and portable electric instruments are presented in Bulletin FB-IR. 4 pages. Federal Pacific Electric Co., Inc., 50 Avenue L, Newark 1, N. J. D

Circle 604 on Page 19

Axial Piston Pump

Offered as a versatile source of hydraulic power or flow, Series A-12900 axial piston pumps deliver 0 to 38 gpm at controlled pressures between 500 and 5000 psi when operated at 3750 rpm. Complete engineering data on these variable displacement pumps are given in Bulletin A5232-A. 10 pages. Vickers Inc., Detroit 32, Mich. H

Circle 605 on Page 19

Annunciator Systems

Organized for quick reference, Catalog 100C on Panalarm annunciator systems explains the functions of various types and their applications for monitoring, control, and other purposes. They give immediate notification of off-normal conditions in continuous process and automatic machine operations. Twelve different systems are described. 52 pages. Panellit, Inc., Panalarm Div., 7401 N. Hamlin Ave., Skokie, Ill. J

Circle 606 on Page 19

Rotary Solenoids

Standard and special solenoids, packaged switch assemblies, and 360-degree drive stepping units are described and illustrated in rotary solenoid products brochure. Engineering specifications and application data are included. 4 pages. Illinois Tool Works, Pacsol Div., 3155 El Segundo Blvd., Hawthorne, Calif. L

Circle 607 on Page 19

Transistors

Suited for use where a large dynamic range and large voltage swings are desired, a line of high voltage NPN and PNP germanium alloy junction transistors simplify Nixie driving and neon bulb circuitry. Transistors are described and application circuitry is included in Brochure G-210. 8 pages. General Transistor Corp., 91-27 138th Place, Jamaica 35, N. Y. D

Circle 608 on Page 19

Pillow Blocks

Unbreakable malleable housings, Timken tapered roller bearings, eccentric locking collar, and labyrinth grease seals are features of pillow blocks described in Catalog BU-102-A. They are supplied factory adjusted and lubricated, ready for use. 4 pages. Browning Mfg. Co., Maysville, Ky. G

Circle 609 on Page 19

Servomotors

Electrical and mechanical specifications, outline drawings, schematics, and torque-speed curves are presented for servomotors, servomotor-rate generators, and inertia-damp and adjustable velocity-damp servomotors in illustrated catalog. The Size 8 units are offered in 115-v, 400-cycle and 26-v, 400-cycle versions. 16 pages. Beckman Instruments, Inc., Helipot Div., 2500 Fullerton Rd., Fullerton, Calif. L

Circle 610 on Page 19

Electric Eyes

Miniaturized electric eye applications include counting, sorting, monitoring, assembling, and automatic weighing in packaging, printing, and general production. Equipment for these uses is described in illustrated Bulletin 571. Technical data include specifications and circuitry. 16 pages. Photomation, Inc., 96 S. Washington Ave., Bergenfield, N. J. D

Circle 611 on Page 19

Differentials

Typical applications of miniature miter and bevel gear mechanical differentials are covered in a pocket-size bulletin. What they are, how they work, and how they are constructed are detailed. 24 pages. PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 612 on Page 19

Data Processing Equipment

Series of three bulletins contain features, specifications, and applications for logic switches, Model 150 tape preparation and editing console, and Model 201 high speed digital plotter. 8, 6, and 4 pages. Tally Register Corp., 5300 14th Ave., N. W., Seattle 7, Wash. M

Circle 613 on Page 19

Control Valves

Digest Catalog 59 contains data on standard air valve models, including envelope dimensions, model numbers, pipe sizes, JIC symbols, and specifications. Cutaway drawings of valves are also included, along with data on pneumatic circuits. 20 pages. Ross Operating Valve Co., 120 E. Golden Gate, Detroit 3, Mich. H

Circle 614 on Page 19

Plastics & Fiber

Information of value in selecting and applying laminated plastics and vulcanized fiber materials for electrical, electronic, and mechanical components is found in condensed catalog. Over 50 plastic grades and six grades of fiber are covered. Properties of each are given. 8 pages. Taylor Fibre Co., Norristown, Pa. E

Circle 615 on Page 19

Hydraulic & Pneumatic Valves

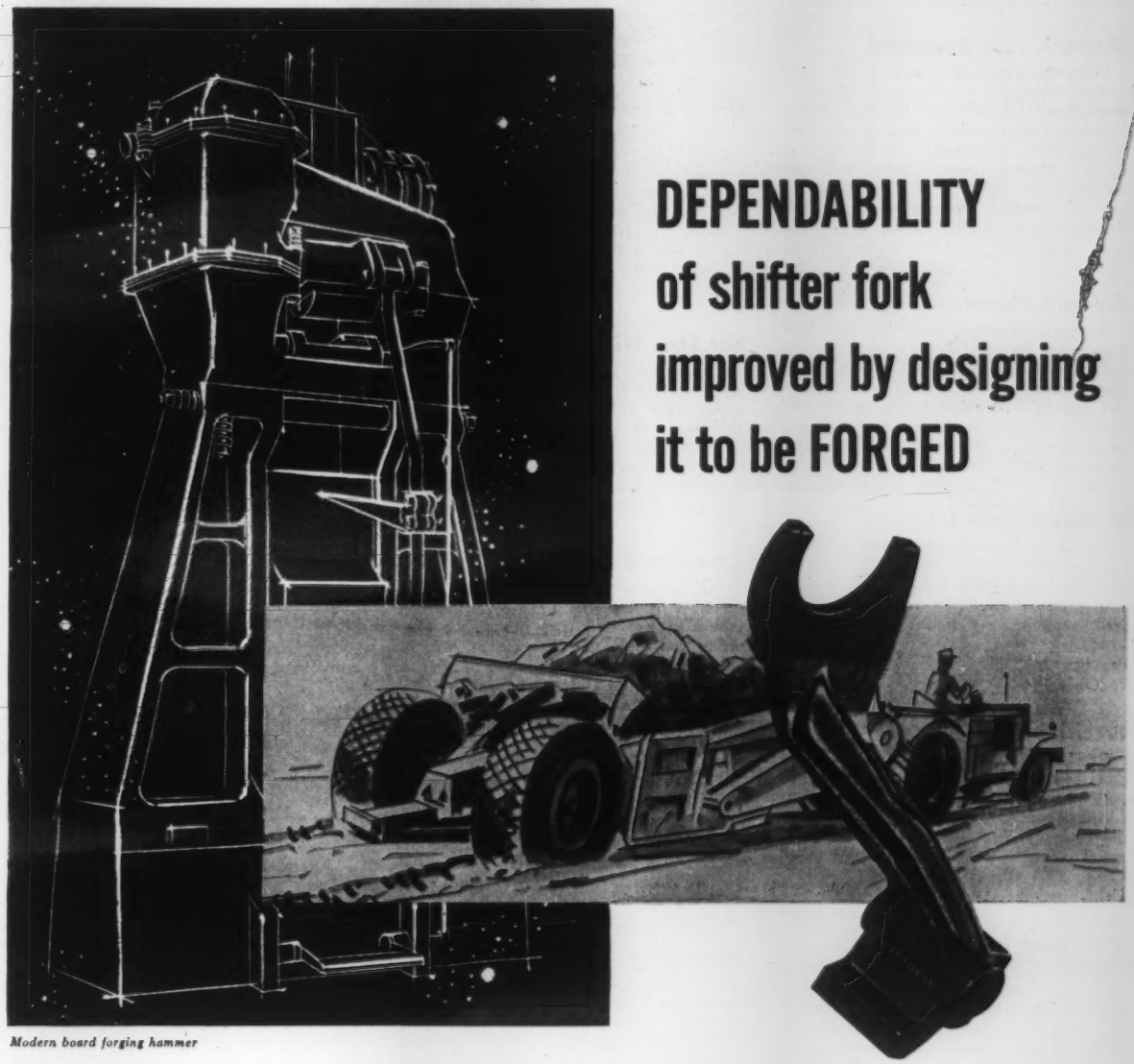
Hydraulic and pneumatic control devices for missiles, rocket engines, and aircraft are subject of brochure. Included are miniaturized components rated 4000 psi in −65 to 400° F range. 8 pages. Hydra-Power Corp., Pine Court, New Rochelle, N. Y. D

Circle 616 on Page 19

Wiring System

Range of types, sizes, and costs of the expanded Insuloid Cradleclip wiring system is presented in illustrated brochure. System either retains cable runs or mounts components with ⅛ to 2-in. diameters. 6 pages. Electrovert Inc., 124 E. 40th St., New York 16, N. Y. D

Circle 617 on Page 19



DEPENDABILITY of shifter fork improved by designing it to be FORGED

Modern board forging hammer

By designing the shifter fork of his transmission to be forged, a manufacturer of earthmovers eliminated costly equipment breakdowns in the field because of fork failure. Factor of safety was *in*creased even while weight and over-all costs were being *de*creased.

Parts scrapped because of voids uncovered after much high-cost machining are eliminated . . . forgings are *naturally* sound all the way through. Forgings start as *better* metal . . . are further *improved* by the compacting hammer-blows or high-pressure of the forging process.

Design your parts to be forged . . . increase strength/weight ratio, reduce as-assembled cost, improve performance. Literature to help you design, specify, and procure forged parts is available on request.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

Magnetic Tape Equipment

Magnetic tape loop transports and reel-to-loop adaptor are subjects of Specifications Sheets DS 3191 and DS 3210. Three instrumentation grade transports are listed for maximum loop lengths of 35, 80, and 100 ft. Adaptor converts Series 3170 reel transports to run 2½ to 15-ft loops. 4 and 2 pages. Minneapolis-Honeywell Regulator Co., 10721 Hanna St., Beltsville, Md. C

Circle 618 on Page 19

Blocks & Sheaves

Tonnage capacities and recommended wire rope sizes are among specifications contained in Catalog I on Durolite blocks and sheaves. Units are made in capacities from 1-ton single blocks to 600-ton multiple sheave assemblies. 10 pages. Sauerman Bros., Inc., 620 S. 28th Ave., Bellwood, Ill. J

Circle 619 on Page 19

Miniature Limit Stop

Useful in many electrical and mechanical installations is the P/N 9501 miniature limit stop with nonlocking mechanical stops. Unit is used in various motorized actuators. Bulletin A-105 affords brief description. 2 pages. United Hydraulics, Inc., 110 Terrell Court, Dayton 7, Ohio. G

Circle 620 on Page 19

Precision Test Gage

Precision pressure measuring test gages described in Bulletin M-28A are available in capacities from 60 to 15,000 psi. The 12-in. diameter gage is calibrated to 360 degrees and requires only 153 sq in. of panel space. 8 pages. Martin-Decker Corp., 3431 Cherry Ave., Long Beach 7, Calif. L

Circle 621 on Page 19

Processing Instrumentation

Continuous level measurement systems, tank or bin level detector-controller, density measuring systems, container fill control systems, container inspection-rejection system, and pipewall thickness gage are among processing instruments described in Bulletin PI-959. 12 pages. Industrial Nucleonics Corp., 650 Ackerman Rd., Columbus 14, Ohio. G

Circle 622 on Page 19

Relay Control Amplifier

Operating principles, performance, and applications relative to the Thermo Electric dc to ac relay control amplifier are covered in Catalog Section 90. This compact vacuum tube amplifier with ±1 microvolt stability is suited to instruments of laboratory accuracy as well as industrial process control systems. 4 pages. Thermo Electric Co., Saddle Brook, N. J. D

Circle 623 on Page 19

Convection Heat Treating

Rate of heat transfer in surface power convection heat treating is increased by raising the velocity of air movement within the chamber to as high as 150 mph. Improved uniformity of heating is achieved. Bulletin SC-182 describes power convection, applications, and shows equipment. 8 pages. Surface Combustion Corp., 2375 Dorr St., Toledo 1, Ohio. G

Circle 624 on Page 19

Nylon Grommet

Safety and installation advantages of the one-piece nylon Flip Grommet are pointed out in folder. Grommet is used with nylon lacing for retention of fuel cell bladders in wet wing structures of aircraft. Specifications and installation are covered. 4 pages. Western Sky Industries, 21301 Cloud Way, Hayward, Calif. M

Circle 625 on Page 19

Hot Strip Width Gage

The Infra-Ray Gage described in Booklet 13-203 is a noncontact, radiation-operated unit which measures and records the width of hot strip traveling at up to 2000 fpm. Measuring techniques are covered. 4 pages. Daystrom, Inc., Daystrom-Weston Sales Div., 614 Frelinghuysen Ave., Newark 12, N. J. D

Circle 626 on Page 19

Tape-Wound Cores

G-L precision-made, tape wound cores described in Bulletin TB-105 can be obtained in two new core materials. Materials and limits are illustrated in booklet and core design data given. 8 pages. G-L Electronics, 2921 Admiral Wilson Blvd., Camden 5, N. J. E

Circle 627 on Page 19

Filter Pumps

A selection guide, listing many electroplating and industrial solutions and their recommended filter pumps, is highlight in Catalog M-1 on Sethco filter pumps. Specs cover 20 models from 50 to 2700 gph capacity. 8 pages. Sethco Mfg. Corp., 2284 Babylon Turnpike, Merrick, N. Y. D

Circle 628 on Page 19

Electronic Counters

General description and detailed specifications for totalizing and predetermined electronic counters are provided in Folder EC201. Units operate entirely through solid state and cold cathode components. Accessories are listed. 4 pages. Redford Corp., Instrument Div., Lake Luzerne, N. Y. D

Circle 629 on Page 19

Measurement & Analysis

"The Panoramic Analyzer" is a publication devoted to the application of panoramic instruments in solving measurement and analysis problems. Techniques for testing as well as equipment for research and development are covered. 8 pages. Publication will be sent regularly. Panoramic Radio Products, Inc., 514 S. Fulton Ave., Mount Vernon, N. Y. D

Circle 630 on Page 19

Linear Potentiometer

Designed to operate at temperature to 500° F, the Model 113 linear motion potentiometer will give precise electrical indication of mechanical position when used with hydraulic actuators, pneumatic valves, and linkage components. It operates with a high level ac or dc signal. Full data are given in Bulletin 113. 1 page. Bourns, Inc., Box 2112, Riverside, Calif. L

Circle 631 on Page 19

Servo Amplifier

The Model 1800-3300 is a high temperature, miniaturized, hermetically sealed, plug-in transistor servo amplifier. It receives signals from synchro control transformer and operates a Size 11, 400 cycle, 3.5 w servo motor. Complete specifications are given in data sheet. 2 pages. M. Ten Bosch, Inc., Pleasantville, N. Y. D

Circle 632 on Page 19

Machine Tool Motors

"Undercover Story" is title of Bulletin SB-191 which tells what to look for in electric motors for machine tool applications. Design, selection, and application data are tabulated. Other factors to be considered in machine tool motor performance are discussed. Also described are direct current motors and generators and variable speed drives. 12 pages. Marathon Electric Mfg. Corp., Wausau, Wis. K

Circle 633 on Page 19

Solid State Power Packs

Details and specifications of the new miniaturized Transpac solid state power packs are given in Catalog Sheet 118. These compact units are available with outputs from 6 to 32 v dc and 2 amp. They operate on alternating current. 1 page. Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J. D

Circle 634 on Page 19

Self-Sealing Fasteners

Various types of high pressure, vibration resistant seals and fasteners are covered in Catalog 359A. Information is given on Seelskrew, Seelbolt, and Seelrivit self-sealing fasteners, and on RubRglas-Seel transparent and flexible wide-angle boots for sealing circuit breakers and indicator lights. Also covered are removable gasket seals, boots, and clear silicone material. 16 pages. A.P.M. Corp., 252 Hawthorne Ave., Yonkers, N. Y. D

Circle 635 on Page 19

Strippable Coatings

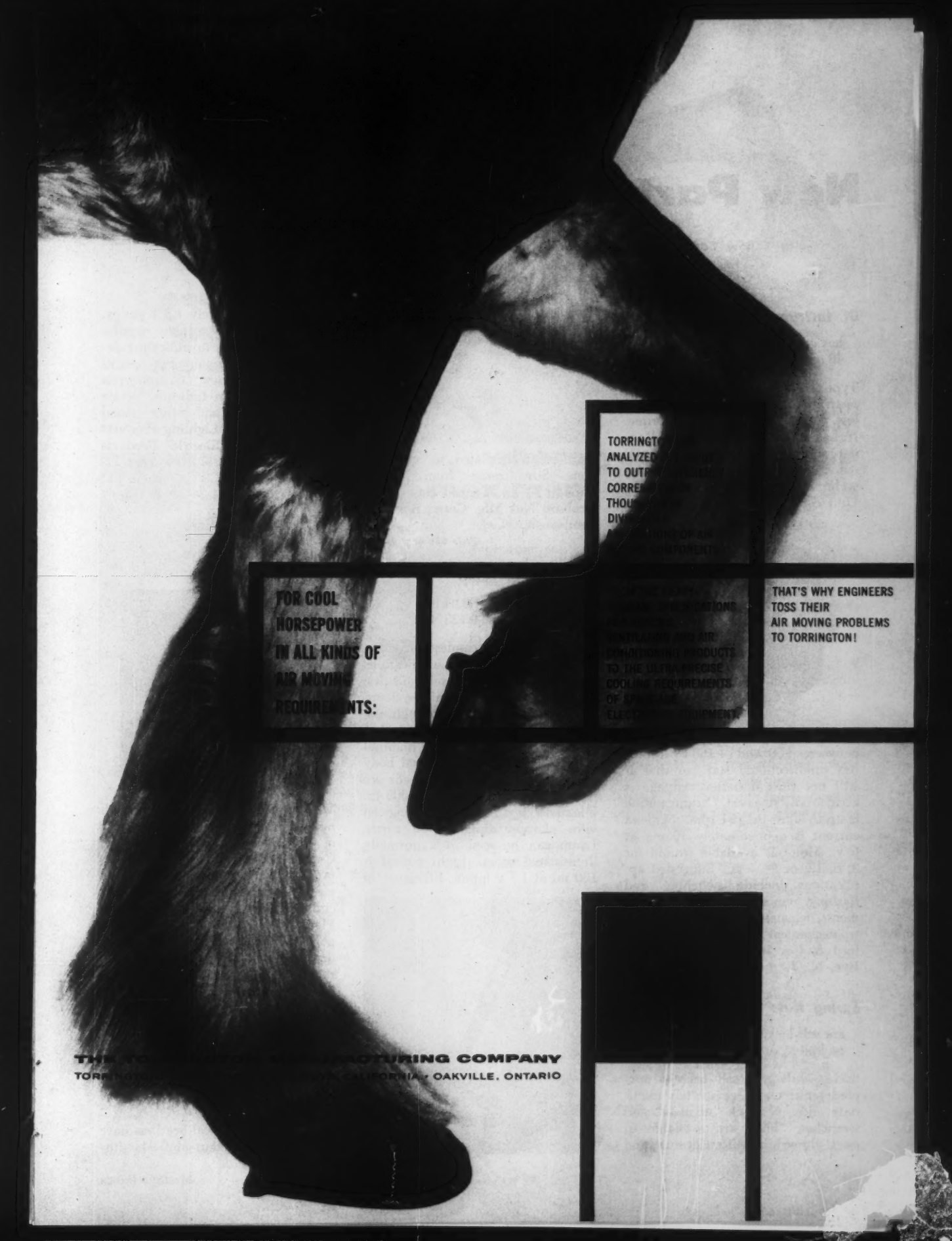
Thermo-Cote strippable plastic coatings are applied to metal tools and parts by merely dipping them in the melted compound. Coatings afford protection against rust, abrasion and corrosion. Properties and uses are outlined in Bulletin 100. 4 pages. Bischoff Chemical Corp., 220 Miller Rd., Hicksville, N. Y. D

Circle 636 on Page 19

Electromechanical Systems

Alternating and direct current motors, linear and rotary actuators, gear boxes, turbine controls, and electromechanical systems are covered in detail in illustrated Catalog EE-100. Also included are descriptions of applications of these devices on aircraft and missiles. 36 pages. Request on company letterhead from Electronic Specialty Co., Eemco Div., 4612 W. Jefferson Blvd., Los Angeles 16, Calif. L

Circle 464 on Page 19→


FOR COOL
HORSEPOWER
IN ALL KINDS OF
AIR MOVING
REQUIREMENTS:
THAT'S WHY ENGINEERS
TOSS THEIR
AIR MOVING PROBLEMS
TO TORRINGTON!
OAKVILLE, ONTARIO

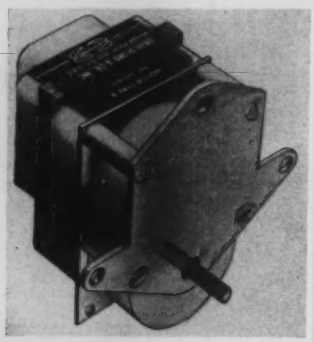
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

DC Instrument Motor

has output torque to 40 oz-in. at 1 rpm

Type B fractional-watt dc instrument motor combines small size and low power drain with high torque. It has neither revolving windings nor sliding commutator. Integral-reduction gear assembly provides wide selection of output speeds. Unit can be supplied for operation



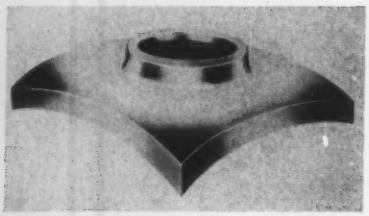
between −50 and +160 F. Motor has unidirectional start so that it will not start if battery voltage is accidentally reversed. Output torque is up to 40 oz-in. at 1 rpm. No-load current is approximately 10 ma at 6 v. Motor is available wound for 3, 6, 12, or 24 v dc. Suggested applications include switching and flashing, remotely controlled instruments, telemetering, and other electromechanical mechanisms. **Brailsford & Co. Inc.**, 670 Milton Rd., Rye, N. Y. D

Circle 637 on Page 19

Spring Nuts

are self-locking, one-piece units

Spring-Nuts are self-locking, one-piece units which completely eliminate use of lock washers and wrenches. They are available in steel, aluminum, silicon bronze, and



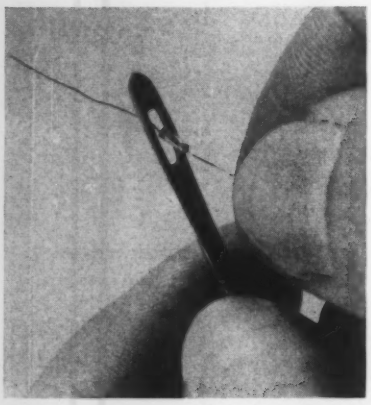
stainless steel, plated to specifications. Sizes range from No. 4 through 3/8 in. Tapped class is 2B. **Jacobson Nut Mfg. Corp.**, Box 177, Kenilworth, N. J. D

Circle 638 on Page 19

Incandescent Lamp

has body diam of 0.04 in. and length of 0.125 in.

Microminiature incandescent lamp, called Mite-T-Lite, has applications in transistorized circuits in missiles, computers, and electronic systems. Small enough to pass through the eye of a darning needle, unit has a cylindrical body with nominal diam of 0.04 in. and nominal body length of 0.125 in. Lamp leads are platinum in a diameter of 0.005 in. Filament is 0.00025-in. tungsten wire of approximately 30 turns. Lamp can be seen in a normally illuminated room. Light output is 100 ml at 1.5 v input. Efficiency of



lamp is approximately 1.5 l per w. Low current and voltage requirements suggest uses in indicating devices in portable equipment operating from batteries. Compactness permits use as an indicator device in pushbuttons and other visual signals. **Sylvania Lighting Products Div., Sylvania Electric Products Inc.**, 730 Third Ave., New York 17, N. Y. D

Circle 639 on Page 19

Printed Circuits

miniature units have high tolerances and clarity

Miniature printed circuits, through new etching process, have tolerances of ±0.0005 in. and high clarity. Copper boards of 1, 2, or 3 oz are produced on a production basis, yet meet high standards for printed circuitry for military applications. Plated-through-hole boards, with gold plated, flash gold, tin plate, or solder-coat plating, together with nickel rhodium tips, are available. **Spec-Tronics**, 13942 Saticoy St., Van Nuys, Calif. L

Circle 640 on Page 19

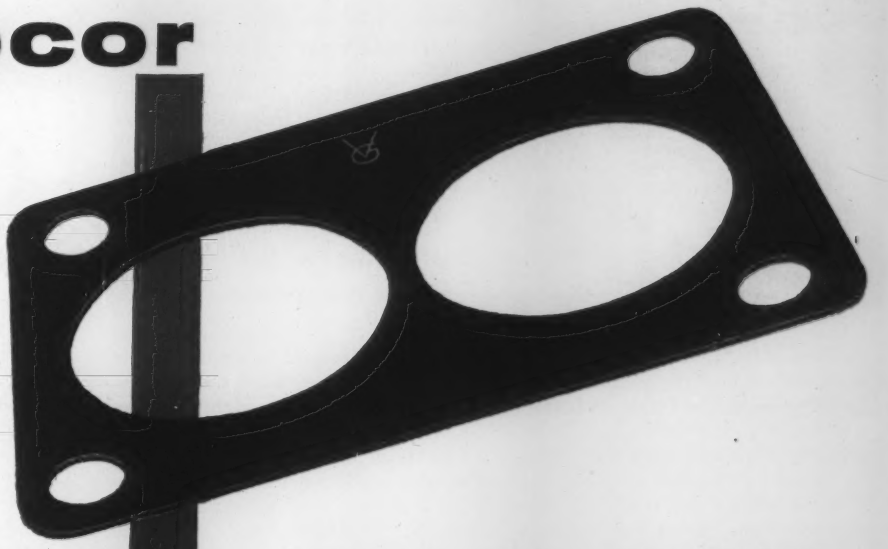
Spherical Bearings

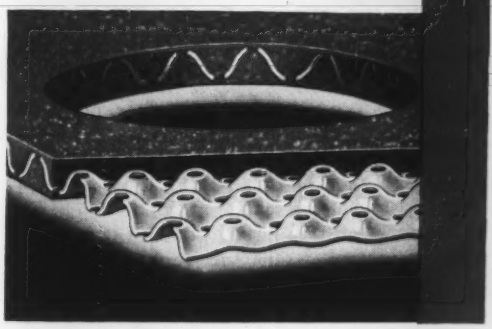
have low coefficient of friction of 0.04

Self-aligning spherical bearings have coefficient of friction of 0.04 with-

Victocor

new super-sealing gasket material





Cross section of **Victocor.** Thin steel core is die-formed with continuous projections alternating in each face. (Type 200 core has 800 projections per sq. in.) Sealing element layers, top and bottom, are bonded simultaneously with core into integral structure. Deep penetration of core projections increases stability and heat conductivity.

TYPICAL PHYSICAL PROPERTIES — TYPE 200

Thickness	.030/.035" min.
% Compressibility at 1000 psi.	*10-15
% Recovery at 1000 psi.	35 min.
% Compressibility at 5000 psi.	*16-21
% Recovery at 5000 psi.	30 min.
Service temperature	750 deg. F.
Crush resistance psi.	100,000
Corrosion resistance against aluminum, magnesium, steel and copper	Good

*Slightly higher values are obtained with heavier gauge.

. . . where you need these maximum characteristics

- low torque loss
- high heat resistance
- high crush resistance
- high dimensional stability
- thin construction— .030/.035 gauge

Victocor justifies re-examination of your most exacting sealing specifications. It's a totally new product—offers more in every desirable heavy-duty characteristic.

Victocor was developed particularly for high-flange-pressure applications. Its steel core construction accelerates heat conductivity. It is strong and highly flexible.

Resistance to hot oils, gasoline and water is excellent, and **Victocor** positively retains all commonly used coolants.

Victocor's sealing element—a special asbestos-elastomeric compound—is extremely resilient. It helps compensate for mating surface irregularities. No coating is required when installing **Victocor** gaskets, and they're easily removed for replacement.

3 Standard Types Available—Test Samples Free

Where can you seal better and more economically with **Victocor?** Let Victor engineers help you decide. It's available in three standard types and many modified combinations. Meanwhile, write for complete technical data and free test samples. Please mention proposed application. Address the factory, or contact your Victor field engineer.

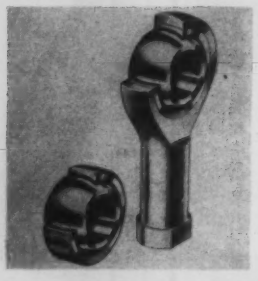
Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill.
Canadian Plant: St. Thomas, Ont.

VICTOR

Sealing Products *Exclusively*

1909 – 1959 50th ANNIVERSARY GASKETS-OIL SEALS

GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS



out use of lubricants such as film, graphite, or molybdenum disulfide. Surface coating of Teflon is bonded directly to outer raceway. Teflon provides chemical inertness, resistance to heat degradation, low-friction, nonsticky surface, and high molecular orientation for toughness and strength. Bearings are suitable for low surface speeds, high unit loads, or applications subject to high dynamic loading where metal-to-metal life is limited by fretting or Brinelling. Field tests find bearings have ten times the life of conventional bronze or steel-on-steel bearings. **Radial Bearing Corp.**, Taylor Street, Danbury, Conn. B

Circle 641 on Page 19

Deceleration Valve

has adjustable throttle

Available for hydraulically actuated machinery, 5-25 gpm deceleration valve permits external adjustment of back pressure to provide desired deceleration rate. To provide proper deceleration characteristics through complete flow range, internal port area is altered by external adjustment. Spool stroke length remains constant regardless of volume setting. Adjustable needle valve permits metering oil through valve when complete shut-off is not desired. Valve can be used for applications up to 60 gpm

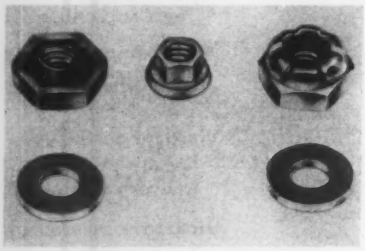
without malfunction. Maximum recommended operating pressure is 3000 psi. Unit is available in either gasket mounting or threaded port designs. **Vickers Inc., Div., Sperry Rand Corp.**, Box 302, Detroit 32, Mich. T

Circle 642 on Page 19

Captive Washer Nut

for use in temperatures to 800 F

Short circuits and other electronic hazards caused by loose washers lost during assembly are eliminated by Kaylock H19320 captive washer nut. Both nut and integrated, free-turning washer together weigh only one-half to one-third as much as AN365, NAS679, and MS20365 fasteners of identical size without washers. Service temperature is 800 F. An identical configuration, H19343, is made for service to



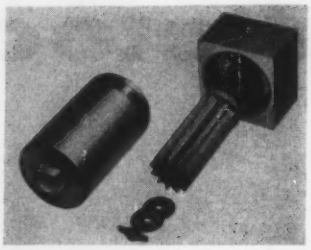
500 F. Both fasteners meet MIL-N-25027 requirements. Thread sizes are No. 2-56 through No. 10-32. **Kaylock Div., Kaynar Mfg. Co. Inc.**, Box 2001, Terminal Annex, Los Angeles 54, Calif. L

Circle 643 on Page 19

Hydraulic Fluid Filter

has reusable filter element

Hydraulic fluid filter features a reinforced, sintered-bronze, 40-micron filter element. In ⅜-in. size, filter area is 35 sq in., assuring long, troublefree service. Design assures that an accumulation of foreign matter causing a pressure drop of as much as 400 psi across element will not cause it to disintegrate. At pressure drops higher than 400 psi, element may crack, but downstream components are protected from particles and small pieces of element. Filter element is reusable, can be cleaned by washing in a solvent and reverse blowing with air. It is con-



tained in a forged-aluminum bowl threaded to an extruded aluminum head. Entire unit is rated at 1000 psi operating pressure. Filter is for use with petroleum, ester, or glycol-based hydraulic fluids, silicones, water, and air. **GPE Controls Inc.**, 240 E. Ontario St., Chicago 11, Ill. I

Circle 644 on Page 19

Printed-Circuit Connector

can be polarized in any position

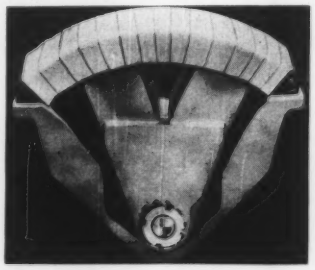
Printed-circuit connector maintains positive contact with printed-circuit board over dimensional range of 0.057 to 0.072 in. It contains 44 contacts which are phosphor bronze with a silver plate of 0.0002 in. and 0.00003-in. gold-plate finish. Plastic polarizing key is furnished with each connector, and key can be inserted into contact slot of any contact position, so that unit can be polarized in any position. **Cinch Mfg. Co.**, 1926 S. Homan Ave., Chicago 24, Ill. J

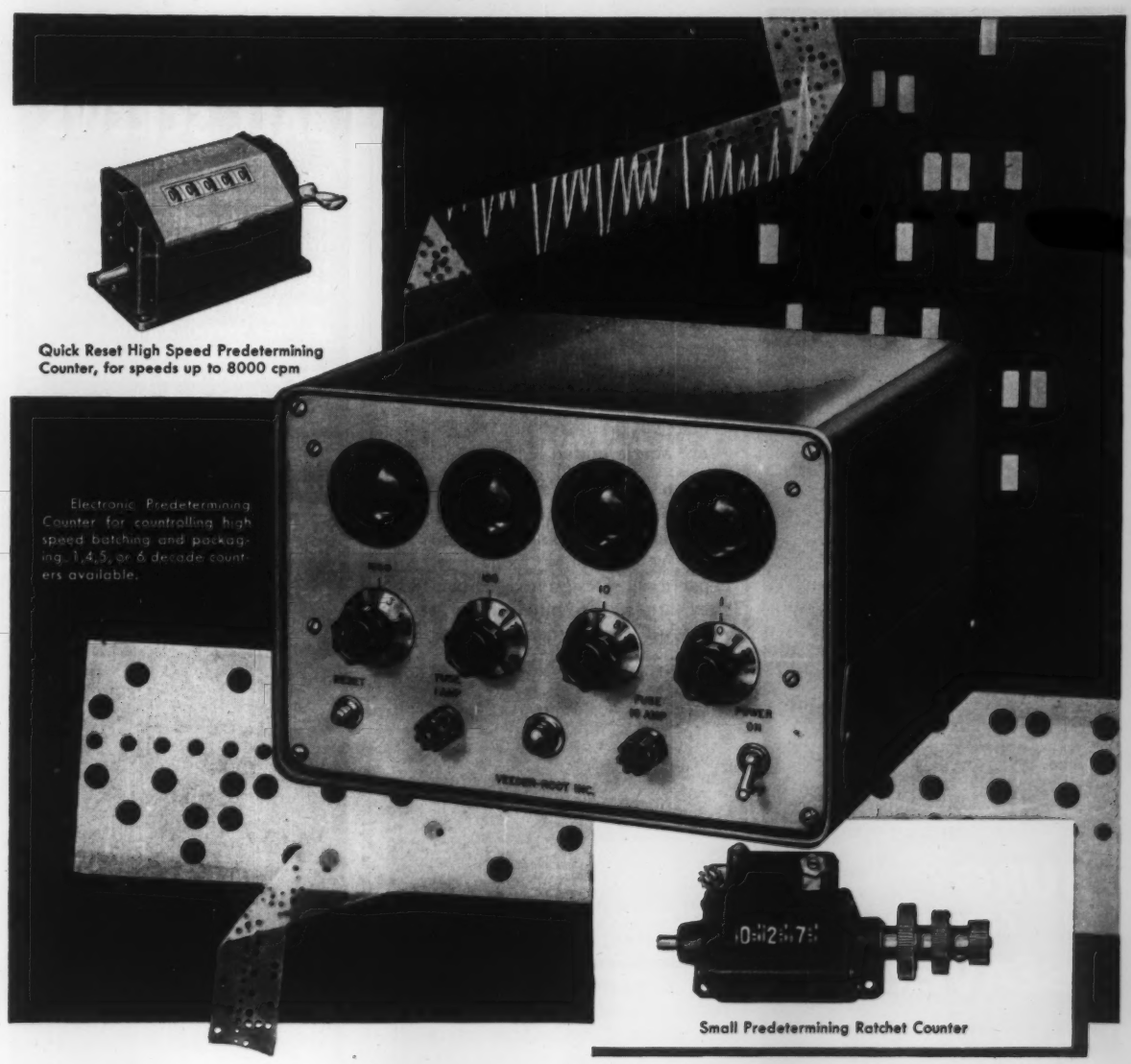
Circle 645 on Page 19

Torque Motors

are dc units with infinite resolution

ARTQ dc torque motors feature high torque-to-power ratio, high torque-to-weight ratio, low heat, full military environmental qualification, and elimination of commutator. There is no brush replacement, friction, radio noise, or explosion hazard. Other character-




Quick Reset High Speed Predetermining Counter, for speeds up to 8000 cpm
Electronic Predetermining Counter for countrolling high speed batching and packaging. 1,4,5, or 6 decade counters available.
Small Predetermining Ratchet Counter

NOW! SIMPLIFIED AUTOMATION AND FEEDBACK CONTROL

. . . with Veeder-Root Predetermining Counters

It's easy to design simplified automation and feedback circuits with Veeder-Root Predetermining Counters.

These devices count turns, strokes, pieces, batches, lengths and similar units to a preset sum and then actuate bells, lights, stop motions, signals and servo systems. Operation is simple, too. Just set a wheel or turn a knob to desired sum and the Veeder-Root counter does the rest.

Send for new folder on the complete line of Predetermining Counters; or a Veeder-Root Counting Engineer can provide design assistance. Call or write:

Veeder-Root

HARTFORD 2, CONNECTICUT

"The Name that Counts"

New York • Chicago • Los Angeles • San Francisco • Seattle
St. Louis • Greenville, S. C. • Altoona, Pa. • Montreal
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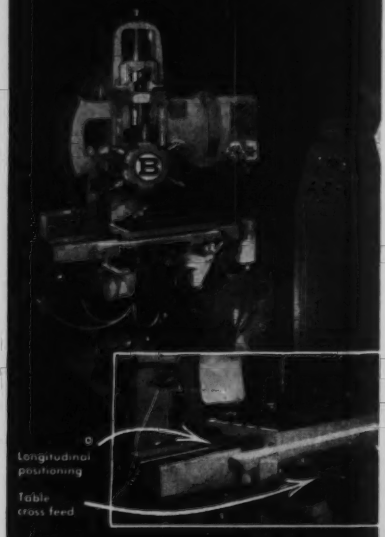
V49-52

AUTOMATIC
POSITIONING
TO ± .001"
RAPID
REPEATABILITY
TO ± .0005"



BURG
DOES IT WITH
'BEAVERS'

Burg Tool Mfg. Co., Gardena, Cal., uses Beaver Ball Screws for obtaining this exceptional precision in their low priced, tape controlled, turret drilling, tapping, boring "Burgmaster Electropoint" and offer with it simplified operation with minimum maintenance.

Most all important machine tool builders use Beaver Ball Screws, particularly in their tape controlled models. We offer complete engineering information and assistance.

Beaver Precision Products INC.
CLAWSON, MICH.

Circle 467 on Page 19

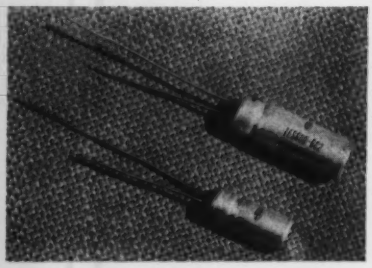
istics include a variety of torque sizes to 200 lb-in., various rotational limits to 60 deg, infinite resolution, better than 1 per cent linearity of torque-versus-input current, and zero slot lock. Motors are available with or without transistor or magnetic amplifier drivers. **Aeroflex Laboratories Div., Aeroflex Corp.**, 34-06 Skillman Ave., Long Island City 1, N. Y. D

Circle 646 on Page 19

Tantalum Capacitors

electrolytic units are single ended

Plug-in type tantalum electrolytic capacitors for printed circuits provide more capacitance in less space than conventional axial-type foil capacitors. Designated Type TES, they are single-ended units which meet all requirements of military



specification MIL-C-3965B, except that both leads emerge from one end. Capacitors contain a noncorrosive wet electrolyte and are rated at −55 to +85 C. They are available with ratings of 3 to 150 v in polar and nonpolar units. Welds of leads are completely encapsulated in epoxy compound. Capacitors are available in ¾ and 1-in. lengths. **Tansitor Electronics Inc.**, West Road, Bennington, Vt. B

Circle 647 on Page 19

Pivots, Shafts, Pins

for miniature precision instruments

Line of miniature pivots, shafts, and pins is available for use in precision instruments, gages, meters, and other products. Pivots are machined from high-grade carbon steel, heat treated for maximum hardness and polished to mirror finish. Conical bearing point angles, from 45 to 70 deg, provide smooth

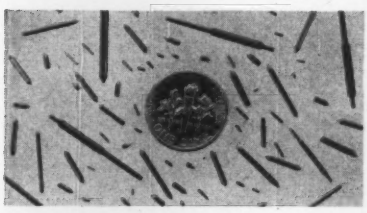
BEAVER
BALL SCREWS

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficient in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments, aircraft, machine tools, massive wind tunnel jacks, etc. For horizontal and vertical actions, indexing, inching and traversing. Consultation and engineering service available. Write for literature.

• EXTREME ACCURATE POSITIONING • NO BACKLASH • RAPID START • ANY DIAMETER OR TRAVEL •

Beaver Precision Products INC.
CLAWSON, MICH.

Circle 468 on Page 19



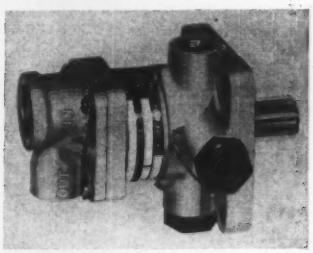
operating performance. Pivots, shafts, and pins are available in diameters from 0.016 to 0.125 in. and lengths from 0.05 to 0.75 in. with radii from 0.008 to 0.004 in. **John Gillen Co.**, 2540 S. 50th Ave., Cicero 50, Ill. I

Circle 648 on Page 19

Hydraulic Pump

for continuous operation at speeds to 50,000 rpm

High-speed hydraulic pump is available in capacities from 0.2 to 11.5 gpm, depending on operating speed and system pressure requirements. Unit is designed for continuous operation at speeds to 50,000 rpm and reduced life operation to 75,000 rpm at discharge pressures to 3000 psi. It is useful particularly in air or gas-turbine applications where weight and cost can be reduced through elimination of gear reduction normally required with other designs. Pump can be furnished as a complete assembly or in a cartridge form for integration into hy-



draulic power packages. In addition to hydraulic fluids, pump handles all ordinary aircraft fuels and many other fluids. **Parker Aircraft Co.**, 5827 W. Century Blvd., Los Angeles 45, Calif. L

Circle 649 on Page 19

Pushbutton Switch

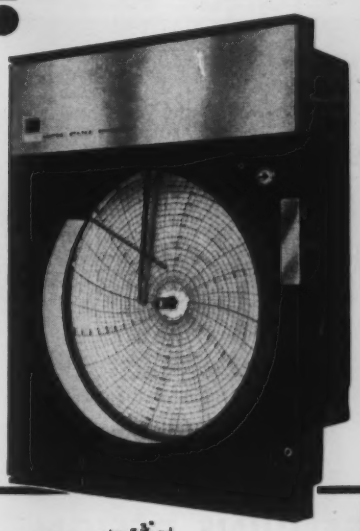
has high cycle life

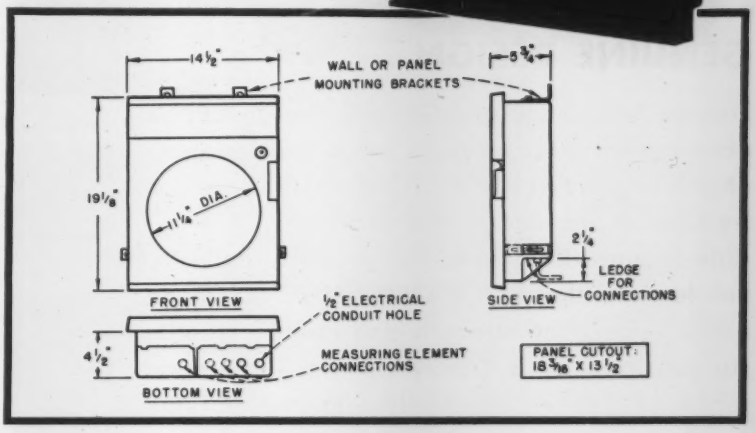
Push-on, push-off, SPST pushbutton switch, No. 1513, is rated at 6

NEW!

MODERNIZED RECORDER HAS UNIVERSAL CASE for all mountings and connections

Also features largest chart opening in the industry





Now, the time-proved, field-proved United States Gauge 12-inch pressure and temperature recorder with completely new, trim, practical exterior design . . . including many important features found only on higher priced instruments. Now, outside and in . . . the USG Recorder offers still more quality, performance and advantages at a money-saving price.

Recessed back. Connections can enter case vertically or horizontally without special mounting.

Largest chart opening in the industry. 11¼-in. diameter for better visibility of chart. Shatterproof glass or blind door optional.

Removable door. New hinge pins permit easy removal of door for access to instrument.

Light weight. Cast aluminum case. Steel back plate provides rigid reference surface for components, prevents recording errors due to stress on case.

Modern design. Enhances modern equipment. Stainless steel escutcheon can be embossed with equipment manufacturer's name.

Fluorescent lighting optional. Ends overheating of case. Improved door skirt increases light on chart.

Dust ledge. Top and bottom. Protects door from dust, moisture.

Ball pivoted pen movements. Exclusive. For 1, 2, 3 or 4 pens.

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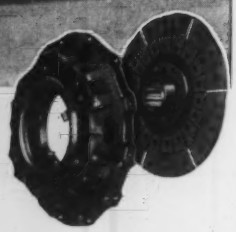
Circle 469 on Page 19

ROCKFORD



TROUBLE FREE THROUGH GENUINE DESIGN

Trouble Free usage and Genuine Design can be obtained for your products when the designing engineer specifies a ROCKFORD CLUTCH. A vast backlog of knowledge and experience is available to him at anytime. The American industry has learned that ROCKFORD CLUTCHES mean extra values. The strength and toughness—the completeness of a Genuine Design—the wide range of sizes—the excellent machining—the long range economies received—all these advantages, and more, of ROCKFORD CLUTCHES combine to create an unexcelled reputation for versatility. Let our engineering staff help you to determine the type and size clutch best suited to help improve the power transmission control in your next model.

Small Spring Loaded

Automotive Spring Loaded

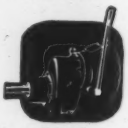
Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs


Speed Reducers

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

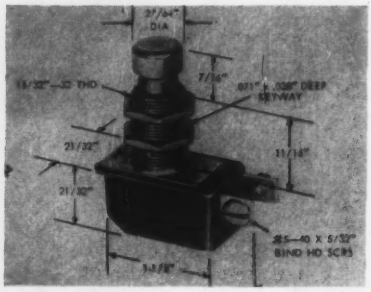
ROCKFORD Clutch Division BORG-WARNER

311 Catherine St., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES



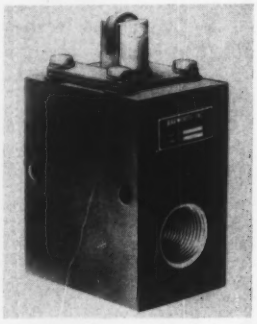
amp, 125 v and 3 amp, 250 v. High-cycle-life switch with positive switching action results from internal-armature design and heavy silver contact. Quick-make, quick-break switch is specifically for appliances and electronic apparatus. **Sargent Electric Corp.**, Dept. R-1, 630 Merrick Rd., Lynbrook, N. Y. D

Circle 650 on Page 19

Cam-Operated Valve

for rated flow of 30 gpm

No. 121 cam-operated valve has maximum operating pressure of 1500 psi and rated flow of 30 gpm. Valve is normally closed, and there is no leakage in closed position. Unit is hydraulically balanced in



closed or open position. Weight is 4½ lb. **Barworth Inc.**, 681 Morris Turnpike, Springfield, N. J. D

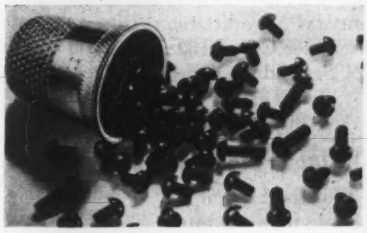
Circle 651 on Page 19

Black Nylon Screws

are furnished in additional sizes

Line of molded black nylon screws has been expanded to include shorter lengths to fit subminiature assemblies and components. Added to round-head line are ¼ and ⅛

in. lengths with No. 2-56 thread sizes. Fillister-head styles include 11 new sizes. All stock lengths have a chamfer and molded lead thread to facilitate starting. Screws eliminate need for special insulating washers or bushings. They are lightweight, nonconducting, nonmagnetic, resistant to corrosion and fungus, and retain exceptional toughness over wide temperature



range. **Weckesser Co.**, Dept. MD-1, 5701 Northwest Highway, Chicago 46, Ill. J

Circle 652 on Page 19

Precision Resistors

are encapsulated in heat-resistant plastic

Molded carbon deposited resistors, designated Carbomold Type CPM, are encapsulated in a strong, reinforced moisture and heat-resistant plastic. Resistors are normally supplied in ±1 per cent tolerance and are available in ranges from 10 ohms to 5 megohms in ½-w size, 10 ohms to 10 megohms in 1-w size, and 30 ohms to 20 megohms in 2-w size. Designed for full load at 70 C and derated to zero load at 150 C, the resistors meet and exceed insulation resistance requirements of MIL-R-10509C. **Hi-Q Div., Aerovox Corp.**, Olean, N. Y. N

Circle 653 on Page 19

Silicon Zener Diodes

have three-layer seal to resist environment

Silicon zener diodes, designed specifically for commercial equipment applications, demonstrate low zener impedance values and very sharp zener knees. They are available in 500 mw and 1 w rated series, and standard RETMA 10 per cent voltage steps from 5:6 to 27 v. All types have a three-layer seal which assures high resistance to humidity,

Only WESPO can supply ALL these
WORK HOLDING DEVICES

TOGGLE CLAMPS and PLIERS 80 Types & Sizes

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Circle 471 on Page 19

Pathon Series WAL . . WHL

AIR AND LOW PRESSURE HYDRAULIC

Cylinders

You can improve the durability and appearance of your equipment with the new Pathon W Series Air and Low Pressure Hydraulic Cylinders.

Valuable space can be saved with these proven screw thread head units. They are available in all standard mounting types plus the type 8, intermediate flange mount (illustrated above) in bore sizes from 1⅛" thru 6".

Specify WAL for air or WHL for oil service to 200 psi. These economical units incorporate non ferrous barrels, hard chrome plated rods, and "U" cup rod packing for minimum friction.

Specify WAT for air service to 250 psi; or WHT for oil service from 350 to 500 psi, depending on bore size. These units incorporate hard chrome plated steel barrels, case hardened, chrome plated rods, and multi-lip rod packing.

All Pathon cylinders have externally replaceable rod packing.

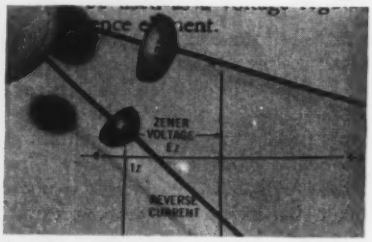
Write for Bulletin #25

Pathon MANUFACTURING COMPANY

3823 PACIFIC AVE. • CINCINNATI 12, OHIO

A-59

FLUID OPERATED AND CONTROL EQUIPMENT



shock, vibration, temperature extremes, and other adverse environmental conditions. **International Rectifier Corp.**, 1521 E. Grand Ave., El Segundo, Calif. L

Circle 654 on Page 19

Oiltight Potentiometers

can be base or one-hole mounted

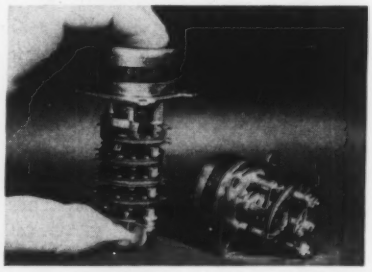
Oiltight potentiometers, complete and ready to mount, are available in three models—a single element, 2-w potentiometer, a dual-element, 2-w unit, and a single-element, 25-w model. All three can be base or one-hole mounted. Operating knob, indicator ring, and subpanel operator are independently adjustable, permitting rapid, sure alignment of all three. **Cutler-Hammer Inc.**, 328 N. 12th St., Milwaukee, Wis. K

Circle 655 on Page 19

Rotary Switch

subminiature unit weighs less than 3 oz

Ledex BD2E rotary switch can be used for stepping, counting, programming, circuit selecting, and homing. Subminiature assembly weighs less than 3 oz and measures only 1.5 in. long and 1.375 in. in diam. Actuated by a rotary solenoid and remotely controlled, it can be self-stepped or externally impulsed. Unit holds up to four 12-position circuit wafers, with 2, 3,



Circle 472 on Page 19

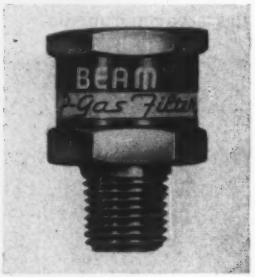
4, 6, or 12-position electrical selective control. Switch meets all applicable environmental tests of MIL-E-5272B. **G. H. Leland Inc.**, 123 Webster St., Dayton 2, Ohio. G

Circle 656 on Page 19

Small Filter

for most small engine conversions

Model F-101 filter with sintered-bronze filter element is 7/8 in. wide, 1 7/16 in. long, and weighs only 2 oz. Filter is suitable for most small engine conversions in fork lifts, farm tractors, and small stationary engines. Element is easily cleaned by blowing out in reverse. Fuel connections are 1/4-in. pipe,



and male outlet permits direct attachment to electric solenoid valve or regulator. Designed primarily for LP-gas, filter works equally well for gasoline and other hydrocarbon fuels. **Beam Products Mfg. Co.**, 3042 Rosslyn St., Los Angeles 65, Calif. L

Circle 657 on Page 19

Rubber-Base Adhesives

for bonding or sealing of irregular mating surfaces

Three adhesives with high solids content and low shrinkage, identified as Bostik 2292, 2293, and 2297, adhere to a variety of materials such as concrete, fabrics, glass, insulating and wallboards, linoleum, metal, paper, plaster, felt, rigid plastic, cork, stone, and wood. Adhesives have resistance to both fresh and salt water, good aging properties, and high resiliency against vibration and impact. No staining oils are present in them, and they can be painted over when dry. Types 2292 and 2293 are both black. The former is extra heavy and does

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Certified
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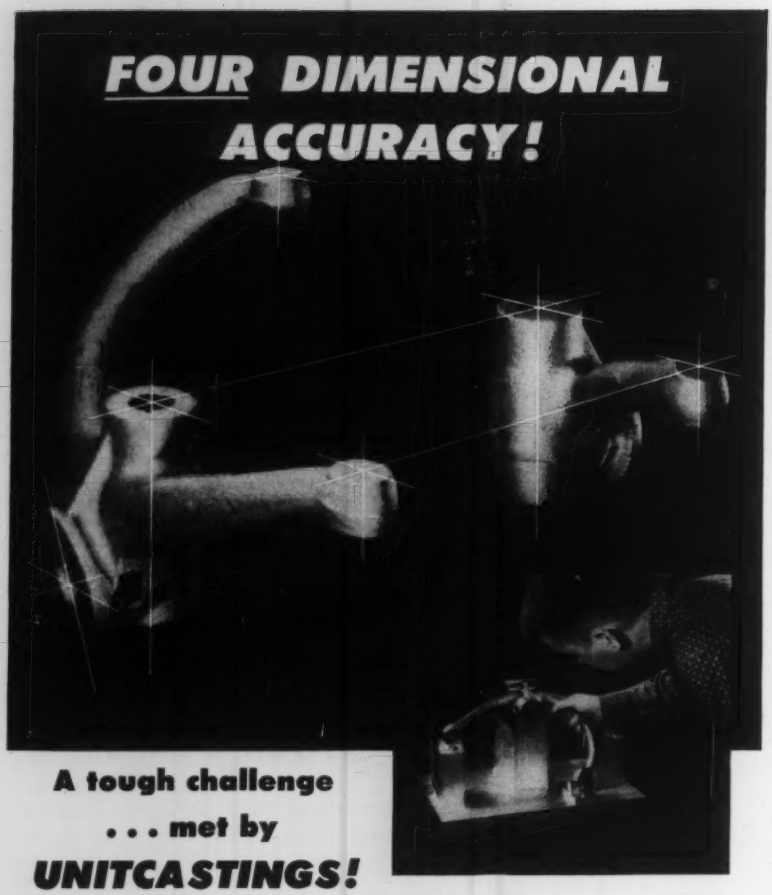
STOCK GEARS
Precision gears of all types, pitches and sizes right out of stock. Each certified for accuracy . . . each meets or surpasses A. G. M. A. specifications.
APPCO Certified Precision Stock Gears are offered in 32, 48, 64, 72, 96 and 120 diametral pitches of 14½° and 20° pressure angles. Each gear is completely sealed on a shipping tray with a plastic cover . . . always "factory-fresh," free of dust, corrosion, and scratches.
APPCO Precision Gears are engineered and manufactured to allow for accurate assembly of precision units . . . held to tolerances that assure precise fits to standard instrument bearings, shafting, etc. according to accepted industry practice and A. G. M. A. specifications. For complete technical data and catalog write to Atlas Precision Products Co., Castor and Kensington Aves., Philadelphia 24, Pa.
APPCO
Division of
PRUDENTIAL INDUSTRIES INC.

Circle 473 on Page 19



A tough challenge . . . met by UNITCASTINGS!

Four-way specifications for this pair of steering arms combined tolerances difficult to hold in sand casting. Structural contour, surface limitations and internal consistency are accepted with regularity at Unitcast. However, a fourth requirement, *relationship of extremities* in such an unusual casting design is a tough problem to solve *economically!*

With a reasonable *finished* cost as an objective, Unitcast's quality control specialists recommended an unorthodox molding method. Special pattern equipment was built to control distortion in the spider-like arms . . . metal flow was redirected along with other unusual procedures. Finally, inspection jigs assured delivered accuracy.

Unitcastings *more* than meet customer's requirements and *cost remained competitive!* Unitcast can offer a similar service for your problems . . . call today for a Unitcast Sales Engineer.

UNITCAST CORPORATION, Toledo 9, Ohio
In Canada: CANADIAN-UNICAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

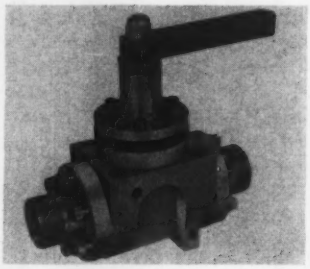
SPECIFICATION STEEL CASTINGS

not tend to run or sag when applied to vertical surfaces. It has approximately 79 per cent solids content and is best applied by trowel or hand gun. No. 2293, which can be applied by brush or trowel, has approximately 66 per cent solids content. It can be applied to only one surface, or can be used as a two-way adhesive. No. 2297 is white, is applied by brush or trowel, and has approximately 61 per cent solids content. The rubber-base adhesives are noncuring and gain in strength for 24 to 48 hr after use. **B. B. Chemical Co.**, 784 Memorial Drive, Cambridge, Mass. B

Circle 658 on Page 19

Manually Operated Valve

1-in. unit handles cryogenic media



Model 115F Flo-Ball valve is a 1-in., manually operated unit available for service with LOX and other cryogenic media at temperatures down to −350 F. Valve has zero external leakage at pressures to 3000 psi and does not require lubrication. Short bonnet assembly is thermally isolated from valve body to provide fast, easy action. Only 25 lb-in. of torque is required to open or close valve at 3000 psi and temperature of −350 F. Unit, which weighs 2 lb, can be line, panel, or side mounted. **Hydromatics Inc.**, 70 Okner Parkway, Livingston, N. J. D

Circle 659 on Page 19

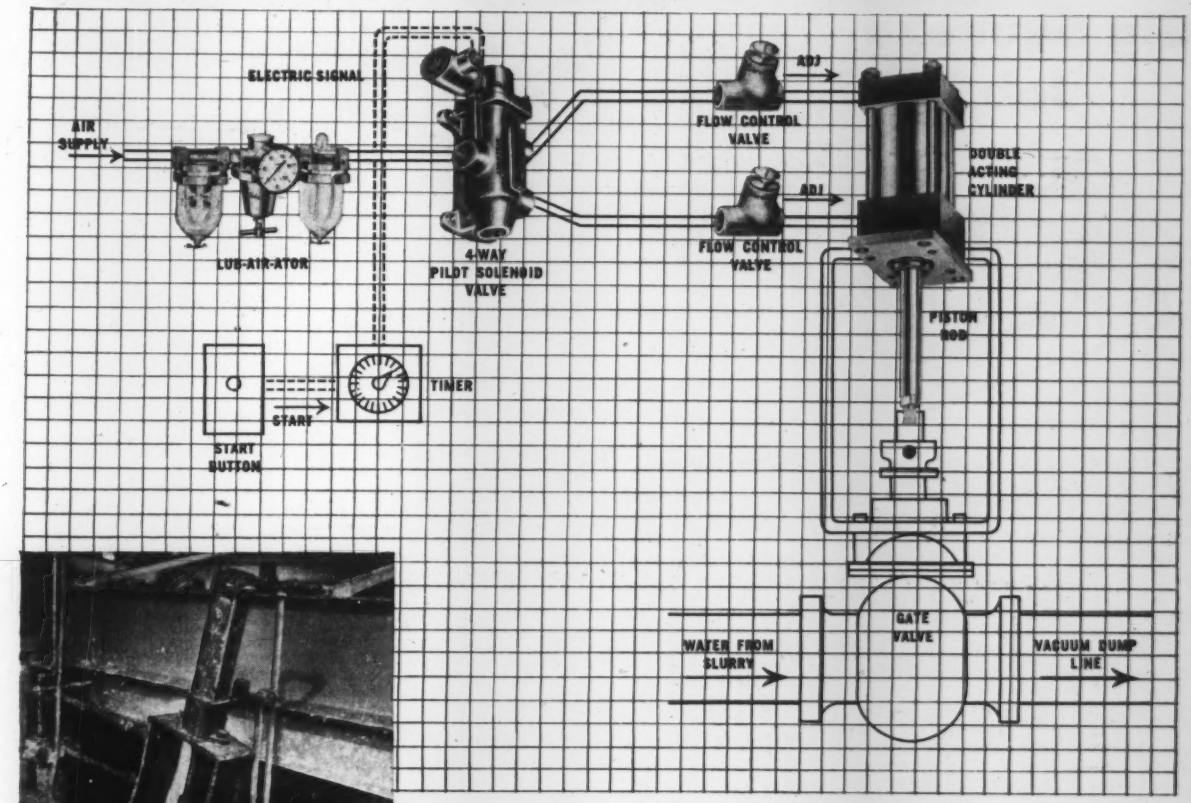
Contact Switch

for actuation by permanent magnet

Mercury-wetted contact switch, Type HGX-1003, is for use as a limit switch, float switch, stepping switch, pulse generator, time base, or in other applications where it

Circle 474 on Page 19

PROCESSOR SPLITS PRODUCTION BOTTLENECK WIDE OPEN WITH HOOKUP OF STANDARD SCHRADER AIR PRODUCTS



Here's how one company automates with air. The hookup of Schrader Air Products in the large diagram actuates gate valves used in processing a slurry of raw asbestos fiber and cellulose at The Republic Seitz Filter Corporation, Newark, N. J. This used to be a slow, arduous manual job. Now air does it quickly, effortlessly, under "conditions particularly difficult for most kinds of automatic equipment . . . without a minute's downtime and without any maintenance whatever," says the company's Technical Director. Schrader-trained air specialists helped plan this practical set-up, as they have helped plan countless others.

Boost productivity of even complex operations quickly and economically, like this company . . . with *air!* Plan it yourself, or let our experts help. A system of Schrader Air Products can simplify almost any bottleneck job . . . whether it's processing, assembling, testing or packaging . . . pushing, pulling, holding, positioning or moving work repetitively.

With Schrader Products, you can run practically any production line faster, safer, more economically—and with tireless accuracy! Maintenance is surprisingly low.

These are benefits every shop needs. Take advantage of them all when you automate with Schrader . . . the finest, the most complete line of Air Cylinders, Valves and Accessories . . . plus countless ideas for cutting your operating costs.

Select air controls from the full Schrader line. Your Schrader distributor can help you pinpoint what you need. For more data, write:

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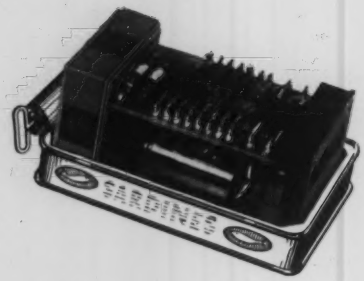
QUALITY AIR CONTROL PRODUCTS

SPECTROL PRECISION MECHANISMS

The Big Squeeze Job



SPECTROL'S new PRECISION MECHANISM—a velocity servo—is more than just another interesting shrink job. It's useful. It can go anywhere you need an ultra-miniature, precision speed control device.

First, the package. It measures only 1½ x 1½ x 3 inches. In a space that would give a sardine claustrophobia, Spectrol engineers squeezed a solid-state amplifier, a servo-motor, a gear train, and a very special, condensed (½-inch long) potentiometer and switch.

The pot has four electrically isolated wipers, all riding 90° apart on the same coil. The switch, in the same pot housing, has four wipers riding on an alternately conducting and non-conducting surface.

THE FUNCTION: The servo accepts dc signals varying between ±10 v from a computer to drive the pot in such a manner that speed is directly proportional to the dc signals.

THE APPLICATIONS: Here's an example: tied to an airborne computer, the Spectrol servo will drive a scope in the cockpit of one of the nation's hottest aircraft. The object: to give the pilot a visual, three-dimensional analog of his position. Actually, the servo will drive anything—resolvers, synchros, tachs, other pots and switches. It's a complete, ready-to-go package you can put into your system as is.

This is another example of how Spectrol PRECISION MECHANISMS free the systems engineer from building functional subassemblies using components such as gear drives, clutches, precision potentiometers and servomotors. If you need modules combining any of these components in a *single specification*—Spectrol can help.

For more details, call your Spectrol engineering sales representative, or address Dept. 5712-A.

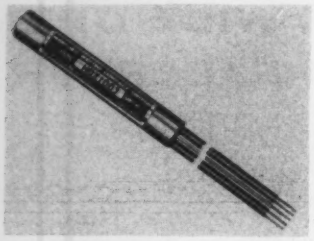
18

SPECTROL

ELECTRONICS CORPORATION

1704 SOUTH DEL MAR AVE. • SAN GABRIEL, CALIF.

Circle 476 on Page 19



can be actuated by a permanent magnet. Switch capsule is sealed in glass and pressurized with hydrogen. Capsule is potted in an impregnated paper tube to make it safe and practical to use with permanent magnets. Unit handles a contact load of 5 amp max, 500 v max, 250 va. **C. P. Clare & Co.**, 3101 Pratt Blvd., Chicago 45, Ill. I

Circle 660 on Page 19

Pillow Blocks

heavy-duty units have eccentric locking collar

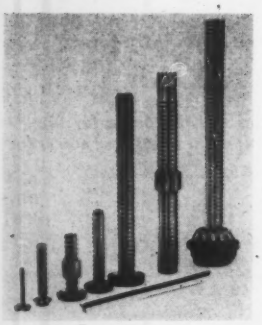
PB900 tapered-roller pillow blocks incorporate unbreakable malleable housings and Timken tapered roller bearings equipped with eccentric locking collar which grips shaft firmly. Labyrinth seals retain lubricant and seal out dirt. Elongated bolt holes permit more adjustment and maximum interchange. Units are available for shaft sizes from 1 3/16 to 4 in. Blocks are completely assembled and ready for use. **Browning Mfg. Co.**, Maysville, Ky. G

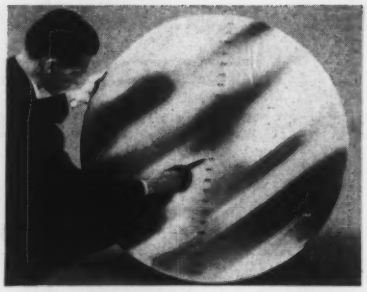
Circle 661 on Page 19

Ball Screw Assemblies

feature internal bypass for recirculating balls

Super-Cision recirculating ball screw assemblies have pitch accuracy to 0.0002 in. per ft. Reduced power requirements permit use of small





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The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
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Dayton Casting Co., Dayton, Ohio
Empire Foundry Co., Tulsa, Okla. and Bonham, Texas
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundries, Inc., Chicago, Ill.
The Hamilton Foundry, Inc., Hamilton, Ohio
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Kennedy Van Saun Mfg. & Eng. Corp., Danville, Pa.
Lincoln Foundry Corp., Los Angeles, Calif.
Nordberg Manufacturing Co., Milwaukee, Wis. and St. Louis, Mo.
Oil City Iron Works, Corsicana, Texas
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
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Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Foundries of FMC, Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Washington Iron Works, Seattle, Wash.
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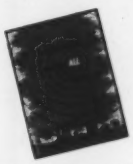

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Circle 662 on Page 19

Molded Nylon Screws

are furnished in three new sizes

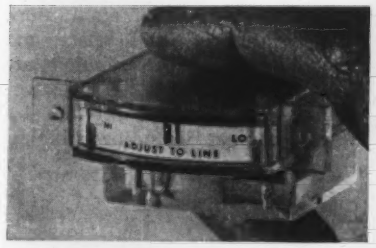
Line of precision-molded nylon screws now includes thread sizes No. 0-80, 1-72, and 4-90. No. 4-90 size, provided with a jewel socket, incorporates ultrafine threads for use in meters, or for any application where compactness and precise adjustments are needed. The other new sizes are molded to Class 2 fit, but can be used with mating threads in assemblies which require Class 3 fits and better by specifying a female thread with tolerances on high side. An excellent electrical insulator, nylon also exhibits high resistance to abrasion, corrosion, and attack by fungus. Expected uses include electrical appliances, electronic assemblies, business machines and computers, and instruments

and controls. Fasteners are available in natural off-white and colors. No. 0-80 and No. 1-72 have fillister heads and lengths of 3/8 and 1/2 in., respectively. No. 4-90 is headless and is 1/4 in. long. **Gries Reproducer Corp.**, 125 Beechwood Ave., New Rochelle, N. Y. D

Circle 663 on Page 19

Edgewise Meter

requires only 0.9 sq-in. panel area



Model 350 edgewise meter has all-plastic housing and clear polystyrene front. Current ranges from 4 ma dc and up, and 10 ma ac. Weight of unit is approximately 2 oz. Scale length is 1.2 in., and unit requires 0.9 sq in. panel area. Meter is for use in applications such as tuning meters for high fidelity, stereo, AM-FM radios, tape recorders, and transmitters, or as indicators on chargers, alarm systems, and control panels. **Shurite Meters**, 130 Wallace St., New Haven, Conn. B

Circle 664 on Page 19

Aluminum Sheet

enamel-coated material is available to 60-in. width

Enamel-coated aluminum sheet, designated Tone-Cote, is available in thicknesses of 0.019 to 0.051 in. and in widths to 60 in. Product is furnished with one or both sides coated. A different color can be applied to each side of sheet, to increase versatility. Nineteen baked-on shades are available on a variety of alloys and specialty products. Straight vinyl, vinyl-alkyd, and acrylic enamels are offered as finishes. Material resists chipping, flaking, peeling, blistering, and cracking. **Aluminum Co. of America**, 791 Alcoa Bldg., Pittsburgh 19, Pa. F

Circle 665 on Page 19

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ENGINEERING DEPARTMENT

EQUIPMENT

Tape Recorder

two-channel unit is subminiature size

Miniature tape recorder is specifically intended for applications where extremely small space and very low power consumption are major considerations. The two-channel unit measures only 5 x 4 x 2 in. complete, including all elec-

tronics, and total weight is 2 lb. Power requirement is only 2½ w dc. Recorder operates at any tape speed to 48 ips, bidirectional, with end-of-tape sensing. Frequency response is up to 160 kc, ± 3 db at 48 ips. Recorder nominally employs 4-in., coaxially stacked reels which hold 900 ft of ½-mil tensilized Mylar tape, ¼ in. wide. **Precision Instrument Co.**, 1011 Commercial St., San Carlos, Calif. M

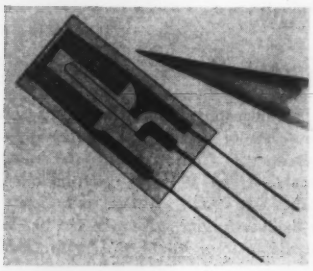
Circle 666 on Page 19

Strain Gage

compensates for temperature on many materials

Dual-element SR-4 foil gage effectively minimizes apparent strain caused by temperature change when bonded to any one of a broad variety of materials. It provides close compensation over a temperature range from about −350 to +850 F. Gage incorporates a platinum-wire compensating element contained within boundaries of a prestabilized, Ni-

chrome-foil, strain-sensing grid. Configuration minimizes inaccuracies caused by rapidly changing temperatures and high thermal gradients. Simple external circuit permits adjustment of temperature re-



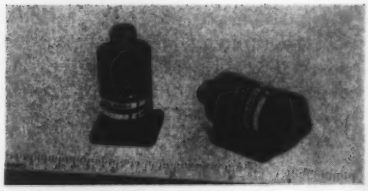
sponse characteristics of gage to compensate on any material, within specified limits of gage, to a high degree of accuracy. Two models are currently available: one is sealed in a phenolic carrier and bonded with epoxy or phenolic cements; the other is supplied on a strippable backing and applied with ceramic cement. Both units have gage length of ½ in. **Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp.**, 42 Fourth Ave., Waltham 54, Mass. B

Circle 667 on Page 19

Miniature Accelerometers

have all-steel construction

For applications requiring precision acceleration measurements, LA34 miniature accelerometers are virtually unaffected by temperature changes. Linearity and accuracy to 1 per cent are provided by the units, which are of all-steel construction. They measure only 1 in. in diam by 1½ in. long and weigh



4 oz. Units are hermetically sealed and employ a glass cylinder—carbon piston damper arrangement for almost zero friction. Instruments withstand severe environmental conditions. **Humphrey Inc.**, 2805 Canon St., San Diego, Calif. L

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Circle 479 on Page 19→

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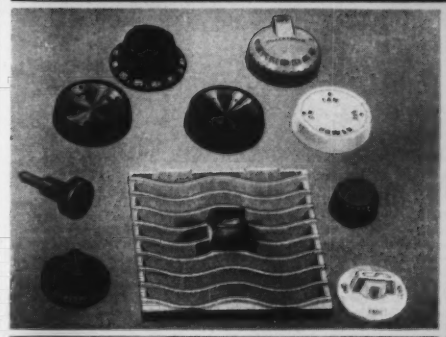
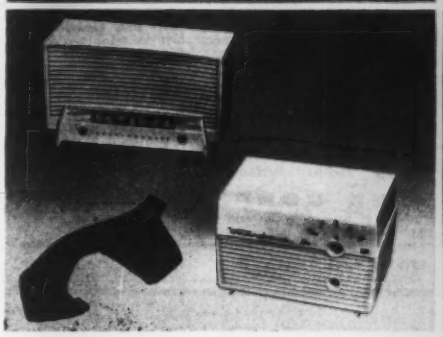
Plastics





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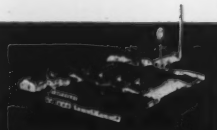

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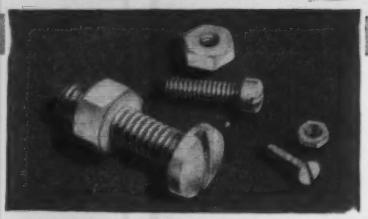

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These advantages, these economies, apply too, to tiny made-to-order parts to your specifications . . . in quantities of 25,000 to many millions. Write for bulletin describing GRC's unique method for injection molding small plastic parts or send prints for quotation. Ask about our zinc alloy die castings, too!

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Recent Books

Nomography. *By Alexander S. Levens, professor of mechanical engineering, University of California at Berkeley; 296 pages, 7 by 9¾ in., clothbound; published by John Wiley and Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$8.50 per copy postpaid.*

Geometric method is employed in the development of basic theory used for design of alignment charts involving three or more variables. Determinant method has been expanded in this second edition and a simple approach to projective transformations may encourage its use.

New chapters discuss circular nomograms and relationship between concurrency and alignment nomographs with applications to experimental data.

Tool Engineering. *By S. E. Rusinoff, professor of mechanical engineering, Illinois Institute of Technology; 362 pages, 5½ by 8½ in., clothbound; published by American Technical Society, 848 East 58th St., Chicago 37, Ill.; available from* MACHINE DESIGN, *$6.75 per copy postpaid.*

Although this book is primarily for tool engineers, design engineers may find it helpful in providing insight into tooling and production. Topics included are tool design, estimating, dimensions and tolerances, and quality control. Analysis and comparison of costs in selecting tools, equipment, and processes best adapted to the product and to future plans of the manufacturer are emphasized.

Standard Mathematical Tables. *By C. D. Hodgman, S. M. Selby, and R. C. Weast; 525 pages, 5½ by 8 in., clothbound; published by and available from Chemical Rubber Publishing Co., 2310 Superior Ave., Cleveland, Ohio; $3.00 per copy.*

This 12th edition includes basic algebraic, geometric, and trigono-

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metric information. Differential equations, integrals, statistics, etc., are also included. Major changes from previous edition are new sections on algebra of sets, reference curves and surfaces, random numbers, and extensions to Fourier series and vector analysis.

Turbulence: An Introduction to Its Mechanism and Theory. *By J. O. Hinze, professor of fluid mechanics, Technological University, Delft, Holland; 586 pages, 6½ by 9½ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$15.00 per copy postpaid.*

Turbulent flow measurement, isotropic and nonisotropic turbulence, and transport turbulent flow processes are presented. Special attention is paid to turbulence in relation to flow resistance and heat and mass transfer. Effect of compressibility of fluid on turbulence phenomena is lightly covered. Instability theories and transition from laminar to turbulent flow are not considered.

Government Publications

NASA Technical Notes. Copies of publications listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

TN D-95. Theoretical Analysis of the Creep Collapse of Columns. By Floyd R. Schlechte, Langley Research Center; 46 pages, 7¾ by 10¼ in., paperbound, side-stapled; $1.25 per copy.

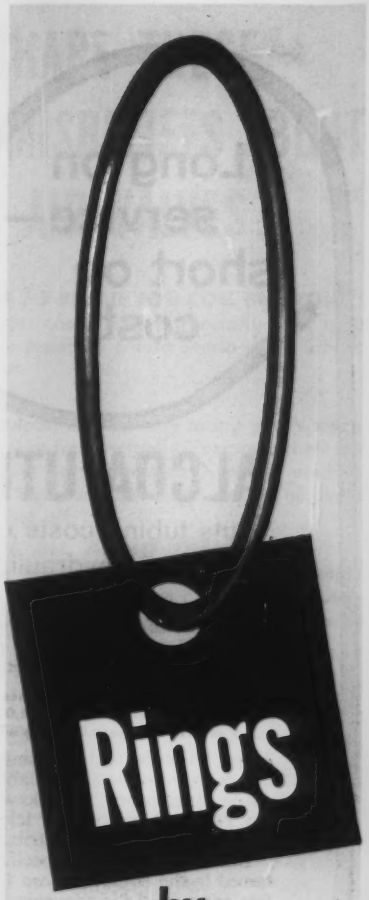
Theoretical analysis attempts to relate material creep properties to creep collapse of idealized H-section columns and solid rectangular-section columns. For rectangular-section columns solutions are obtained for both linear and nonlinear stress distribution through the thickness of the column. Charts give critical lifetime parameters based on these various theories. Previously published data for rectangular-section columns are compared with theoretical results.

TN D-104. Minimum-Weight Analysis of Symmetrical-Multiweb-Beam Structures Subjected to Thermal Stress. By Robert R. McWithey, Langley Research Center; 30 pages, 7¾ by 10¼ in., paperbound, side-stapled; $0.75 per copy.

Minimum-weight analysis based on buckling and yielding stresses is presented. Curves of minimum structural weight and optimum values of the beam parameters are shown as a function of bending moment. Examples are given for using the curves to obtain minimum-weight beams.

TN D-181. Investigation of Creep Behavior of Structural Joints under Cyclic Loads and Temperatures. By Leonard Mordfin, Nixon Halsey, and Gary E. Greene, all of National Bureau of Standards; 37 pages, 7¾ by 10¼ in., paperbound, side-stapled; $1.00 per copy.

Eighty-two structural-joint specimens were tested. Specimens were fabricated from 2024-T3 clad aluminum-alloy sheet riveted with 2024-T31 aluminum-alloy rivets and from 17-7 PH (TH 1050) precipitation hardening stainless-steel sheet. Two types of joints in stainless steel were tested: Spot-welded and riveted with ¼ in. high-shear rivets. Results indicate certain trends which permit estimation of the cyclic creep behavior of joints.



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Circle 481 on Page 19

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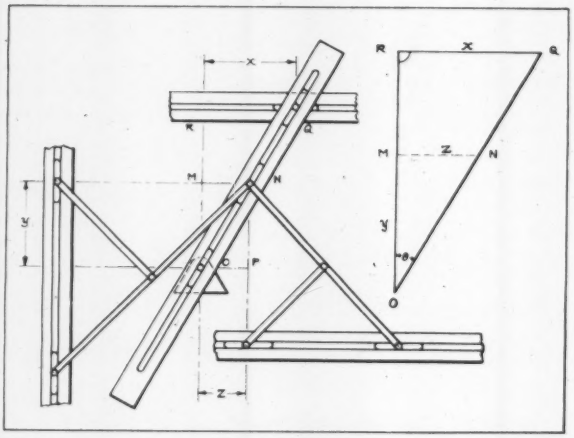
Circle 482 on Page 19

NOTEWORTHY

Patents

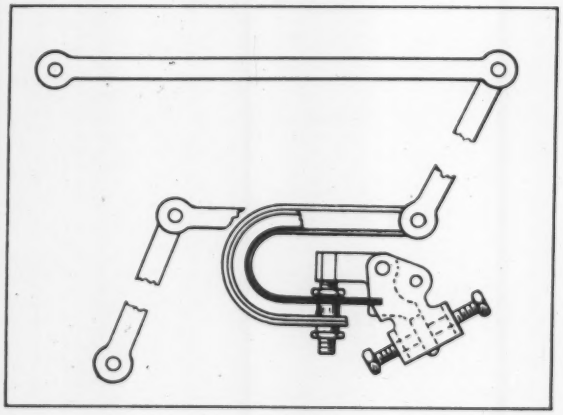
Multiplication Linkage

A graphic multiplier functions on the principle of similar triangles. Fixed members include three slides, either parallel or perpendicular to each other, and one pivot, point *O*. In addition to one slide, movable



members include linkages which terminate in sliders and join all members of the assembly. Projections through pivot *O* yield a diagram in which tan $\theta = Z/Y = X$. Hence, $Z = XY$. *Patent* 2,910,227 *assigned to the United States of America (Air Force) by Thomas R. Silverberg.*

Temperature-Compensating Link



A selection of bimetallic elements comprise an adjustment member which changes cyclic displacement

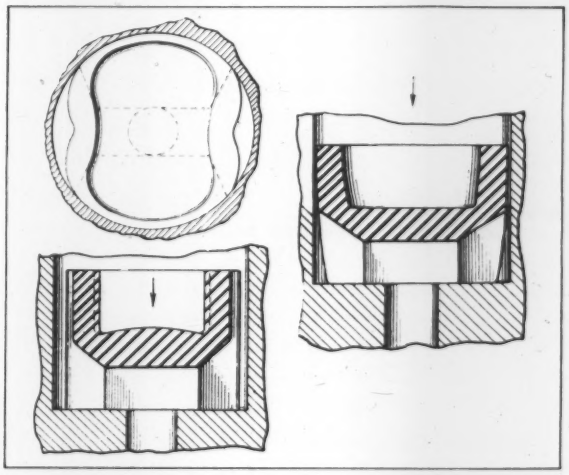
of a linkage to account for changes of temperature. Nested in the shape of a U, the bimetallic elements are graduated in thickness, the thinnest forming the inner contour of the U. This construction assures that each U-shaped lamina deflects equally. *Patent* 2,912,859 *assigned to American Meter Co., Philadelphia, by Robert R. Douglas.*

Nonlinear Diaphragm

Spoke-like radial corrugations, tapered in depth, enable a diaphragm to deflect nonlinearly under fluid pressure. Supplementing this action are annular corrugations which act like hinges at the rim and hub of the diaphragm. Depending on material thickness and the depth of corrugations, diaphragms can be made sensitive or strong. Momentary overloads of pressure can be as high as 30 times the normal operating range. *Patent* 2,913,008 *assigned to the United States of America (Commerce) by Fidel Cordero.*

Dilating Flow-Control Device

Variations of pressure in a fluid line are moderated by a resilient cup which tends to expand and block the line as pressure in the line increases. The lip of



the cup faces upstream. Under normal conditions, the cup allows flow through two irregularly shaped passages formed between its outer wall and the inner wall of the conduit. As pressure and flow in the line increase, static pressure in the bowl of the cup, and dynamic pressure due to flow, push the lip radially outward. *Patent* 2,910,093 *assigned to the Dole Valve Co., Chicago, by Robert R. Dahl.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

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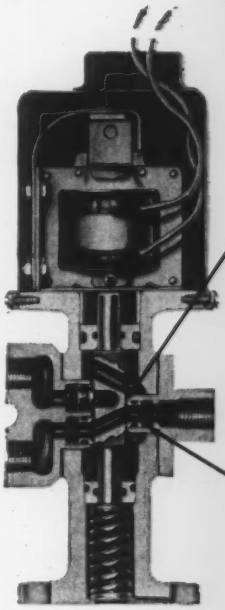
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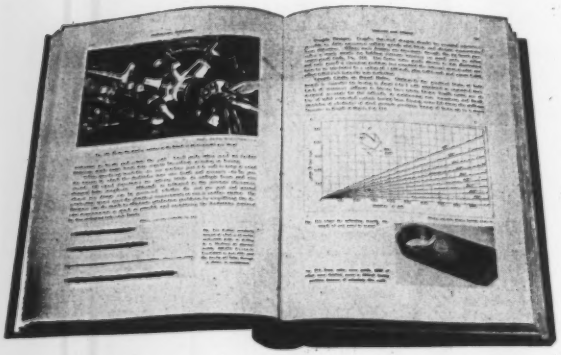

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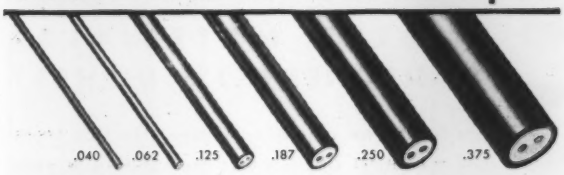

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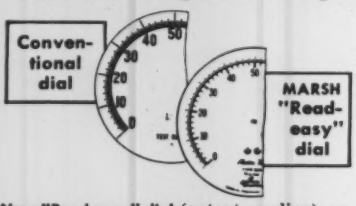

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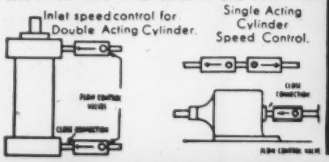

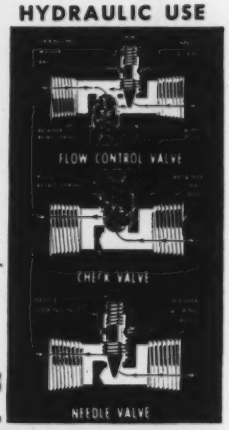

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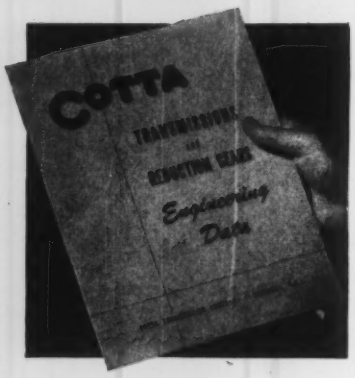

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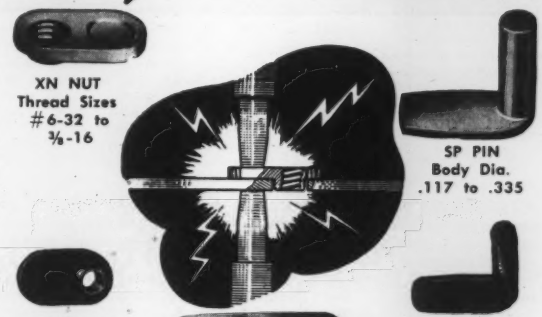

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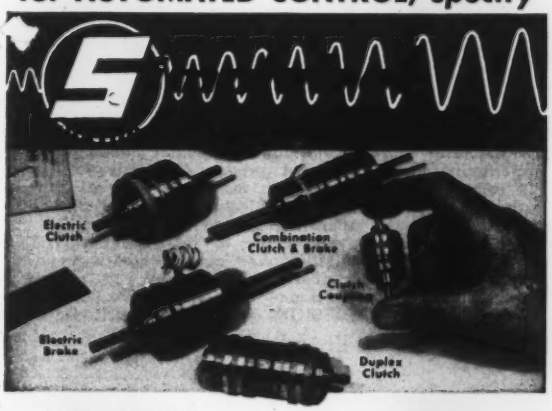

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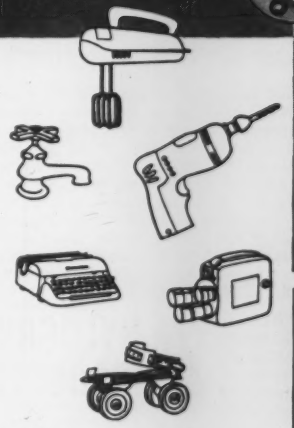

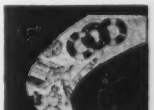

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MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

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BPA NBP

backtalk——

—Dirty Work

This issue's cover and Page 92, both of which appear to have been run over by one each small tank and truck, introduce a series of articles on off-the-road vehicle design by M. G. Bekker, a man who really knows his subject from the ground up. In fact, he has been invited to help organize the First International Conference on Soil-Vehicle Systems, to be held in 1961 in Italy under the auspices of leading Italian universities.

Mr. Bekker is chief of the Land Locomotion Research Laboratory, U. S. Army Ordnance Tank-Automotive Command. He has also been, a staff member of the Operations Research Office of Johns Hopkins University; a research professor in the Stevens Institute of Technology graduate school and head of the Motor-Vehicle Laboratory; head of research in vehicle mobility, Canadian Dept. of National Defense; and a special lecturer at the University of Michigan graduate school. He is a graduate of Warsaw Institute of Technology and a retired lieutenant colonel of the Canadian army.

Besides a number of articles, Mr. Bekker has written a book, *Theory of Land Locomotion—the Mechanics of Vehicle Mobility*. A second book on off-the-road locomotion will be published next summer.

—By Any Other Name

You may not recognize it right off, but the following story is probably the first one you ever heard. This version, part of an article entitled, "A Pig Is a Pig Is a Pig," by A. Q. Mowbray, assistant editor of the *ASTM Bulletin*, appeared in the October issue of that journal.

> The following describes the activities of five immature mammals of the family of nonruminant artiodactyl ungulates. All five of these may be described as being of less than average magnitude; however, no information is given as to the relative size of one with respect to another. Available evidence indicates that the first of the group proceeded in the direction of an area previously established for the purpose of commerce. Data on the second of the group clearly show that, at least during the time period under consideration, it remained within the confines of its own place of residence. Reports received on the activities of the third member of the group seem to show conclusively that it possessed an unknown quantity of the flesh of a bovine animal, prepared for consumption by exposure to dry heat. The only information available on the fourth member of the group is of a wholly negative nature, namely, that its possessions did not include any material of the type previously described as having been in the possession of its predecessor in this discussion. As to the fifth and last member of the group, fairly conclusive evidence points to its having made, during the entire course of a movement in the direction of its place of residence, a noise described as "wee, wee, wee."

"Try that one," says Mr. Mowbray, "on your two-year-old's piggies. Ten to one you lose your audience before you draw your second breath." Neither ASTM nor MACHINE DESIGN presumes to instruct in nursery-type storytelling technique, but the situation has a parallel in engineering writing. The little piggies involved may grow up to fill an engineer's shoes, and the technical mind on the other end of them will still appreciate and respond to plain talk.

—Astute Sayings Dept.

Looking through the contents of this issue, which includes two articles on fasteners, we recalled the anecdote about a little girl's brief essay on a bolt and nut. She reportedly described threads on the bolt as "scratching wound around the end" and threads on the nut as "wrinkles around the inside of a hole." We decided to try this stunt on our favorite seven-year-old, so we placed the suitable hardware before her and requested a description. "That's a bolt and nut," she said. "It's for putting things together."

—The Day Before Christmas

Most technical magazines, including MACHINE DESIGN, stick strictly to their business, no matter what's going on in the outside world. Such singleness of purpose is a Good Thing, of course, but just this once, since an issue comes out on Christmas Eve, we are going to mention the holiday. So, as you sit beside your aluminum tree with its foamed and molded plastic ornaments, open up your packages of synthetic ties and slide-rule tie clips, tinker with the new toaster, and mentally redesign the kids' toys—remember that we're wishing you a good old-fashioned Christmas.

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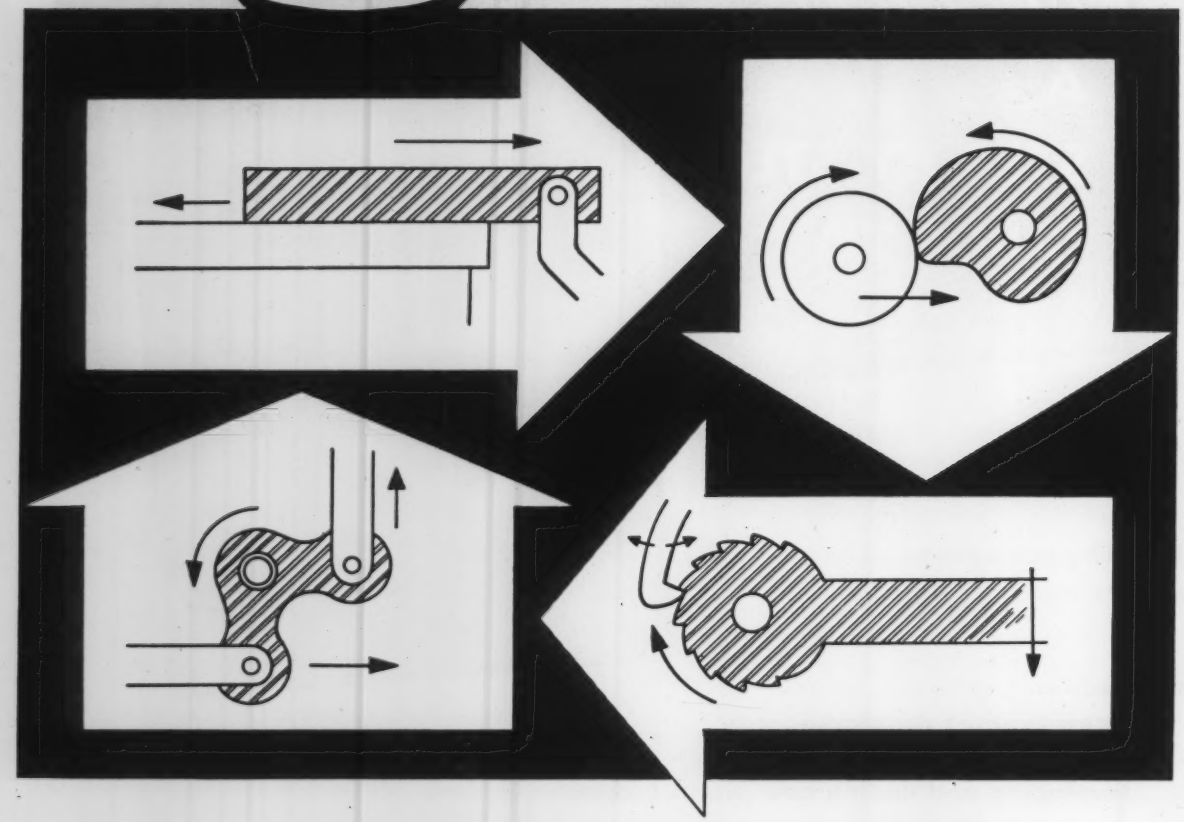

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Circle 496 on Page 19

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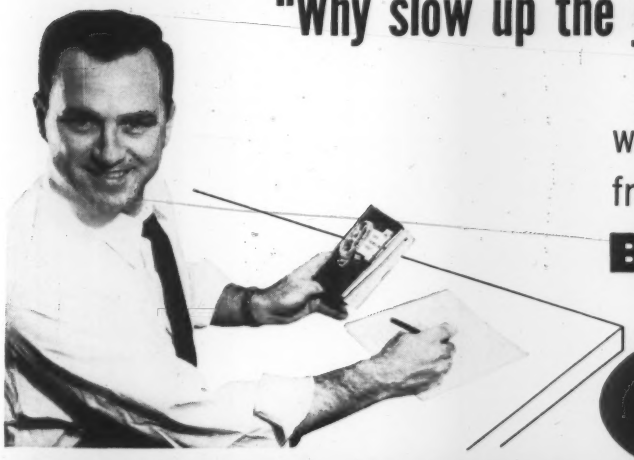

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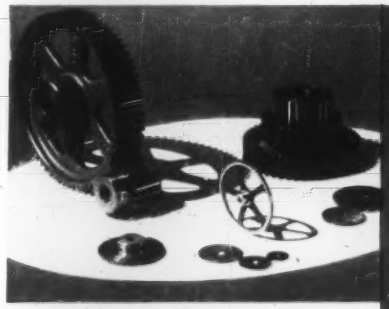

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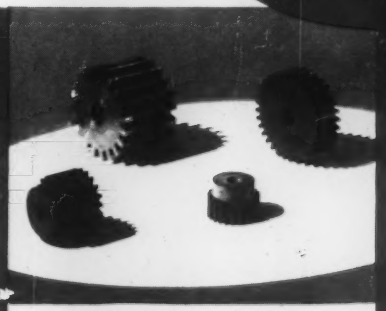

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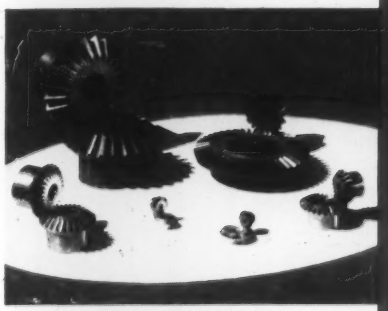

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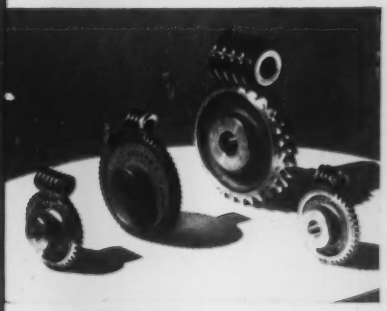

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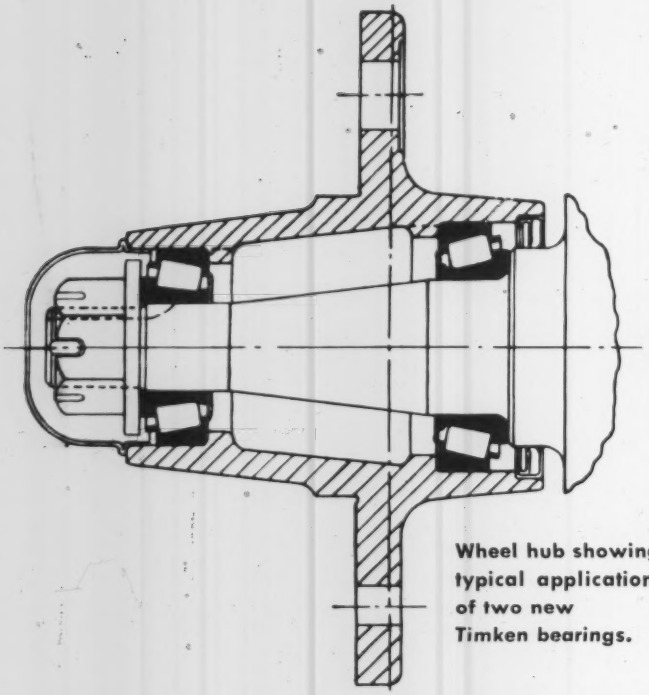
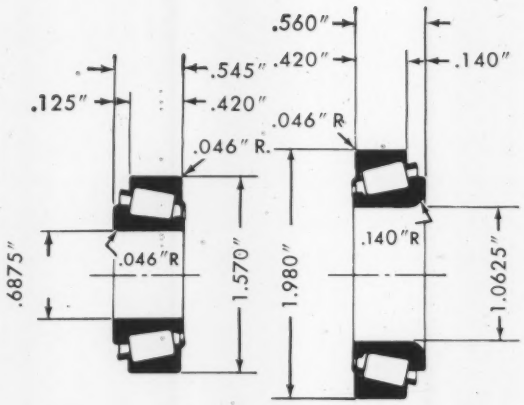
— STANDARDIZATION PAYS —

Circle 402 on Page 19

Three new, low-cost TIMKEN® bearings open new design opportunities



Wheel hub showing typical application of two new Timken bearings.



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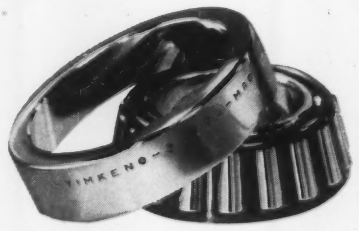

TIMKEN® TAPERED ROLLER BEARINGS ROLL THE LOAD

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